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The Impact of Synaesthesia and Absolute Pitch on Musical Development

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Abstract

This dissertation investigated the impact of synaesthesia and absolute pitch (AP) on musical development. Synaesthesia is a rare neurological condition in which the stimulation of one sense modality leads to an automatic, involuntary experience in a second sense modality. While synaesthesia is more prevalent among arts professionals, and is linked to enhanced memory and creativity, no studies to date have examined the impact of synaesthesia on musical development. A review of the literature uncovered that AP - the ability to label a given note in the absence of a reference note - was often reported to co-occur with synaesthesia. Synaesthesia and AP are thus two uncommon neurological conditions that require involuntary and stable mappings between perceptual and verbal representations.

The purpose of this study was to identify the degree to which synaesthesia or AP possession may facilitate or impair the cognitive, affective, and behavioural outcomes of musical development, and to investigate the potential interaction between synaesthesia and AP for participants who possess both conditions. In order to fulfil these objectives, a mixed-methods study was devised which involved thirty-five students and academic staff members of the Melbourne Conservatorium of Music, the University of Melbourne (Australia). The data collected from each participant consisted of information obtained from an online survey, a semi-structured interview, and synaesthesia and AP test batteries.

A cognitive-affective-behavioural model of musical development was formulated to provide a framework for the organisation of the results collected. The results of this study indicate that synaesthesia and AP initially impact musical development at a cognitive level, by enhancing memory encoding and multimodal mental imagery. Enhancements in these domains exert a developmental influence on affective states, specifically motivation, identity, and emotion. These affective outcomes influence musical behaviour, notably choices, preferences, and performance. Both enhancements and limitations to cognitive, affective, and behavioural outcomes were recognized as being influenced by the possession of synaesthesia or AP. Ultimately, however, all participants indicated they would retain their condition(s) if given the choice, with advantages outweighing any negative aspects. Furthermore, a phenomenological analysis of both conditions demonstrated that the overwhelming majority of AP cases in this study meet the diagnostic criteria for synaesthesia. While further research is needed to test and confirm this claim, synaesthesia and AP are conjectured to be phenomenological variants of the same condition.

The results fulfil an important initial role of uncovering and recounting the unique lived-world experiences of these musicians, and have implications for how musicianship is taught to students who possess synaesthesia and AP. This study has broadened understandings of the effects of synaesthesia and AP on musical development, and of the complex relationship that exists between these two conditions and musical potential and ability. Findings support evidence from other areas by demonstrating a positive link between synaesthesia and memory, data organisation, and creative inspiration, while additionally expanding this link to include AP.

Declaration

I, Solange Glasser, declare that this thesis comprises only my original work towards the degree of Doctor of Philosophy. Due acknowledgement has been made in the text to all other material used. The thesis is fewer than the maximum word limit of 100,000 words in length, exclusive of tables, maps, bibliographies and appendices.

Signed,

Solange Glasser

10 April 2018

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For as long as I can remember I only ever had two dreams: to have four children, and to obtain a PhD. Challenging: yes, but incompatible: no.

The ultimate reward for achieving my dreams is that I am now able to dream anew.

Table of Contents

Abstract ..... **i**

Declaration ..... **iii**

Acknowledgements ..... **iv**

Table of Contents ..... **vii**

List of Figures ..... **xiii**

List of Tables ..... **xiv**

Chapter 1: Introduction **1**
1.1. Purpose of the Study **4**
1.2. Organisation of the Dissertation **5**

Chapter 2: Review of the Literature **8**
2.1. Synaesthesia **9**
2.1.1. Forms of Synaesthesia 9
2.1.2. Definition of Synaesthesia 11
2.1.2.1. Perceptual and cognitive types of synaesthesia. 12
2.1.2.2. Unimodal, bimodal, and multimodal forms of synaesthesia. 17
2.1.3. Diagnosing Idiopathic Synaesthesia 18
2.1.3.1. Synaesthesia is involuntary and automatic. 19
2.1.3.2. Synesthetic percepts are consistent and generic. 20
2.1.3.3. Synesthetic percepts are spatially extended. 22
2.1.3.3.1. Projector and associator synesthetes. 22
2.1.3.3.2. Lower and higher synesthetes. 24
2.1.3.4. Synaesthesia is memorable. 25
2.1.3.5. Synaesthesia is affect-laden. 26
2.1.3.6. Key points. 27
2.1.4. History of Synaesthesia Research 27
2.1.5. Prevalence 31
2.1.5.1. Prevalence and gender 32
2.1.5.2. Prevalence of different forms of synaesthesia. 34
2.1.6. Synaesthesia and Musical Ability 35
2.1.6.1. Synaesthesia and memory. 36
2.1.6.2. Synaesthesia and specific musical abilities. 38
2.2. Absolute Pitch **39**
2.2.1. Definition of Absolute Pitch 39
2.2.1.1. Absolute pitch lies along a continuum. 40
2.2.1.2. Classification of absolute pitch possessors. 40
2.2.1.3. Absolute pitch, quasi absolute pitch, and relative pitch 42
2.2.2. Prevalence of Absolute Pitch 42
2.2.3. Diagnosis of Absolute Pitch 43
2.2.4. Genesis of Absolute Pitch 43
2.2.4.1. Absolute pitch as an inherited trait 43
2.2.4.1.1. Absolute pitch ability often appears at a young age 44
2.2.4.1.2. Absolute pitch tends to run in families. 44
2.2.4.1.3. The neurological underpinnings of absolute pitch. 45
2.2.4.1.4. The prevalence of absolute pitch in different ethnic groups. 46
2.2.4.2. Absolute pitch acquired through intensive practice. 48
2.2.4.3. Absolute pitch and early life exposure. 49
2.2.4.3.1. Type of musical training. 50
2.2.5. Implicit Absolute Pitch 52
2.2.5.1. Pitch production. 52
2.2.5.2. Pitch identification. 53

2.2.6. Absolute Pitch and Musical Ability 54
2.2.6.1. Absolute pitch and pitch memory. 55
2.2.6.2. Absolute pitch and musical dictation. 56
2.2.6.3. Absolute pitch and interval identification. 57
2.2.6.4. Absolute pitch and relative pitch processing. 57
2.3. Synaesthesia and Absolute Pitch Research 58
2.3.1. Study 1 59
2.3.2. Study 2 60
2.3.3. Study 3 61
2.3.4. Study 4 61
2.3.5. Study 5 62
2.4. Summary 63

Chapter 3: Design and Methodology 64
3.1. Choice of Method 65
3.1.1. A Description of Mixed Methods Research 66
3.1.2. Challenges and Benefits of a Mixed Methods Approach 66
3.1.3. Determining Key Design Principles 67
3.1.3.1. Determining the level of interaction. 67
3.1.3.2. Determining priority. 68
3.1.3.3. Determining timing. 68
3.1.3.4. Determining procedures. 69
3.1.4. Choice of Type of Mixed Methods Design 70
3.1.4.1. The embedded design. 71
3.2. Description of Sample 72
3.2.1. Reason for Choosing Synaesthesia and Absolute Pitch 72
3.2.2. Ethics Clearance 73
3.2.3. Sample Used in the Study 74
3.2.3.1. Recruitment of sample. 74
3.2.3.2. Final participant sample. 76
3.3. Measures and Procedure 77
3.3.1. The Research Survey 77
3.3.1.1. Demographic information. 78
3.3.1.2. Musical history. 78
3.3.1.3. Absolute pitch and synaesthesia. 79
3.3.1.4. Medical history. 80
3.3.1.5. Format of the online survey 81
3.3.2. The Interview 81
3.3.2.1. Producing knowledge through the interview. 82
3.3.2.1.1. Thematising the interview. 83
3.3.2.1.2. Designing the interview. 84
3.3.2.1.2.1. Thematic and dynamic questions. 85
3.3.2.1.2.2. Narrative interview form. 86
3.3.2.1.3. Conducting the interview. 87
3.3.2.1.3.1. The interview stage. 87
3.3.2.1.3.2. Briefing. 87
3.3.2.1.3.3. The interview. 89
3.3.2.1.3.4. Debriefing 89
3.3.2.1.4. Transcribing the interview. 90
3.3.2.1.5. Analysing. 91
3.3.2.1.5.1. Bricolage form of interview analysis 91
3.3.2.1.6. Verifying 92
3.3.2.1.6.1. Validity 92
3.3.2.1.6.2. Reliability. 93
3.3.2.1.6.3. Generalisability. 93
3.3.2.1.7. Reporting. 94
3.3.2.1.7.1. Ethical reporting 94
3.3.2.1.7.2. The final report. 94

3.3.2.1.7.3. Structuring the interview report. 95
3.3.2.2. Key points. 96
3.3.3. Synaesthesia and Absolute Pitch Test Batteries. 96
3.3.3.1. Synaesthesia test battery. 96
3.3.3.1.1. Reliability and validity of the synaesthesia test battery. 97
3.3.3.1.2. Administering the synaesthesia test. 98
3.3.3.2. Absolute pitch test battery. 99
3.3.3.2.1. Pitch labelling. 100
3.3.3.2.2. Quantifying absolute pitch ability. 101
3.3.3.2.2.1. Piano tones stimuli. 101
3.3.3.2.2.2. Pure tones stimuli. 102
3.3.3.2.2.3. Chordal stimuli. 103
3.3.3.2.3. Administering the absolute pitch test battery. 104
3.3.3.2.4. Response type. 105
3.3.3.2.4.1. Pointing to the piano. 105
3.3.3.2.4.2. Pitch-class wheel. 105
3.3.3.2.4.3. Pitch identification among alternatives. 106
3.3.3.2.4.4. Identifying name and octave. 106
3.3.3.2.4.5. Identifying pitch class. 107
3.3.3.2.5. Scoring the absolute pitch test. 108
3.4. Organisation of Results Chapters 4-7 108
Chapter 4: Cognition 111
4.1. Memory 112
4.1.1. Synaesthesia. 113
4.1.1.1. Synaesthesia as a mnemonic aid. 114
4.1.1.2. Synaesthesia as a structural cue. 116
4.1.1.3. Synaesthesia and overcoming difficulties. 119
4.1.1.4. Key points of synaesthesia and music memorisation. 121
4.1.2. Absolute Pitch. 121
4.1.2.1. Absolute pitch as a mnemonic aid. 122
4.1.2.2. Structural cue. 123
4.1.2.3. Absolute pitch and overcoming difficulties. 125
4.1.2.3.1. Cooper: short-term memory deficiency and absolute pitch. 126
4.1.2.4. Absolute pitch and increased speed of memorisation. 128
4.1.2.5. 'Sound bank' and absolute pitch development. 129
4.1.2.5.1. Noah. 129
4.1.2.5.2. Lucas. 131
4.1.2.5.3. Oliver. 134
4.1.2.6. Key points of absolute pitch and music memorisation. 136
4.1.3. Summary of Memory 137
4.2. Imagery 138
4.2.1. Unimodal Mental Imagery. 140
4.2.1.1. Auditory imagery. 140
4.2.1.2. Absolute pitch, auditory imagery, and associated benefits. 143
4.2.1.2.1. Oliver: positive effect of auditory imagery highlighted through a rare case of its loss. 145
4.2.1.3. Key points of unimodal mental imagery. 147
4.2.2. Multimodal Mental Imagery: Synaesthesia and Complex Visual Imagery 147
4.2.2.1. Auditory imagery inducing synaesthesia. 149
4.2.2.1.1. Synaesthesia inducing auditory imagery. 150
4.2.2.1.2. Key points of the function of auditory imagery in synaesthesia. 152
4.2.2.2. Complex visual imagery. 153
4.2.2.2.1. Unfamiliar scenes. 155
4.2.2.2.1.1. Case study 1: Ethan. 155
4.2.2.2.1.2. Case study 2: Charlotte. 158
4.2.2.2.1.3. Case study 3: Matilda. 162
4.2.2.2.1.4. Key points of unfamiliar scenes. 163
4.2.2.2.2. Familiar scenes. 163
4.2.2.2.2.1. Case study 4: Mason. 164

4.2.2.2.2.2. Case study 5: Lucas (absolute pitch possessor)....165
4.2.2.2.2.3. Key points of familiar scenes....167
4.2.2.2.3. Key points of involuntary complex visual imagery....168
4.2.3. Summary of Imagery....169
4.3. Summary of Cognition....170

Chapter 5: Affect....172
5.1. Motivation....173
5.1.1. Descriptive Statistics of Motivation....174
5.1.1.1. Motivation to commence musical training....174
5.1.1.2. Motivation to continue musical training at a tertiary level....175
5.1.2. Intrinsic Motivation....177
5.1.2.1. Relationship with music....177
5.1.2.1.1. Enhanced enjoyment of music....178
5.1.2.1.2. Enhanced connection to music....181
5.1.2.1.3. Key points of relationship with music....186
5.1.2.2. Purpose....186
5.1.2.2.1. Synaesthesia and absolute pitch as a 'sign' or 'gift'....187
5.1.2.2.2. Career change motivated by a 'gift'....189
5.1.2.2.3. Wasted 'gifts'....192
5.1.2.2.4. Key points of purpose....194
5.1.2.3. Autonomous regulation and competence....195
5.1.2.3.1. Self-directed learning....195
5.1.2.3.2. Practical aid....198
5.1.2.3.3. Key points of autonomous regulation and competence....200
5.1.3. Summary of Motivation....201
5.2. Identity....202
5.2.1. Synaesthesia and Absolute Pitch as a Special or Defining Characteristic....203
5.2.1.1. Within-group differentiation....207
5.2.2. Increased Popularity and Pride....210
5.2.3. Fear of the Loss of Synaesthesia or Absolute Pitch....214
5.2.4. Summary of Identity....217
5.3. Summary of Affect....218

Chapter 6: Behaviour....222
6.1. Descriptive Statistics of Facilitated and Hindered Tasks....223
6.2. Preferences and Choices....227
6.2.1. Stylistic Preferences and Repertoire Choices....227
6.2.1.1. Concert programming choices....231
6.2.1.2. Music listening preferences and aversions....233
6.2.2. Compositional Choices....237
6.2.3. Instrument Preferences....245
6.2.4. Summary of Choices and Preferences....248
6.3. Performance....250
6.3.1. Interpretation....250
6.3.1.1. Synaesthesia....251
6.3.1.2. Absolute pitch....254
6.3.2. Technique....257
6.3.3. Transposition....260
6.3.3.1. Playing a transposing instrument....264
6.3.3.2. Different pitch systems: baroque and classical pitch....266
6.3.3.2.1. Listening to music at baroque pitch....267
6.3.3.2.2. Performing at baroque or classical pitch....269
6.3.4. Summary of Performance....271
6.4. Summary of Behaviour....274

Chapter 7: Synaesthesia and Absolute Pitch: Interactions and Comparisons....277
7.1. Interaction of Synaesthesia and Absolute Pitch....278

7.1.1. Synaesthesia and Absolute Pitch: The Question of Dominance 280
7.1.2. Synaesthesia and Absolute Pitch: The Question of Interaction 281
7.1.3. Synaesthesia and Absolute Pitch: The Question of Separability 283
7.1.4. Summary of the Interaction of Synaesthesia and Absolute Pitch 285
7.2. Phenomenology of Inducers and Concurrents 286
7.2.1. Phenomenology of Inducers 286
7.2.1.1. Synaesthesia inducers. 287
7.2.1.2. Absolute pitch inducers. 289
7.2.2. Phenomenology of Concurrents 290
7.2.2.1. Synaesthesia concurrents. 290
7.2.2.2. Absolute pitch concurrents. 294
7.2.2.2.1. Note characteristic or personification as concurrent. 295
7.2.2.2.2. Visual concurrent. 298
7.2.2.2.3. Tactile concurrent. 303
7.2.3. Summary of the Phenomenology of Inducers and Concurrents. 307
7.3. Summary of Synaesthesia and Absolute Pitch: Interactions and Comparisons. 310

Chapter 8: Discussion 312
8.1. Summary of the Key Findings 314
8.1.1. Key Findings of Aim 1 315
8.1.1.1. A cognitive-affective-behavioural (CAB) model of musical development. 316
8.1.1.2. Individualised responses and between-group similarities. 319
8.1.1.3. Results that support and extend previous findings. 320
8.1.1.3.1. Synaesthesia, absolute pitch, and cognitive outcomes. 320
8.1.1.3.2. Synaesthesia, absolute pitch, and affective outcomes. 322
8.1.1.3.3. Synaesthesia, absolute pitch, and behavioural outcomes. 324
8.1.1.4. Unexpected results. 325
8.1.1.4.1. Discussion of complex visual imagery. 325
8.1.1.4.2. Discussion of the development of a 'sound bank', and redefining absolute pitch. 330
8.1.2. Key Findings of Aim 2 332
8.1.2.1. Absolute pitch and the five diagnostic criteria of synaesthesia. 334
8.1.2.1.1. Absolute pitch: involuntary and automatic. 335
8.1.2.1.2. Absolute pitch: consistent and generic. 336
8.1.2.1.3. Absolute pitch: spatially extended (associator versus projector). 337
8.1.2.1.4. Absolute pitch: memorable. 338
8.1.2.1.5. Absolute pitch: affect-laden. 339
8.1.2.1.6. Summary of absolute pitch and the five diagnostic criteria of synaesthesia. 340
8.2. Implications for Research 342
8.2.1. Implications for Individual Musicians. 343
8.2.2. Implications for Practice. 344
8.3. Future Research 347
8.3.1. Secondary Template of Absolute Pitch 348
8.3.2. Synaesthesia, Absolute Pitch, and Autism 349
8.3.3. The Impact of Synaesthesia and Absolute Pitch on Musical Development During Childhood. 349
8.3.4. The Impact of the Age-related Loss of Synaesthesia and Absolute Pitch on Professional and Personal Musical Engagement 350

Chapter 9: Conclusion 352
9.1. An Experiential Feedback Model of Musical Development 356
9.1.1. Are Synesthetes and Absolute Pitch Possessors Differently Packaged Individuals? 358
9.1.2. Are We All The Same? 360
9.1.3. Summary of the Experiential Feedback Model. 361
9.2. Significance of the Findings 362
9.3. Final Personal Reflection 363

Reference List **365**

Appendices **386**

Appendix A. **387**

A.1. Participants with Synaesthesia and Absolute Pitch or Quasi Absolute Pitch 388

1. James 388
2. Mason 390
3. Ella 391
4. Xavier 393
5. Samuel 395
6. Benjamin 397
8. Olivia 401
9. Mia 402
10. Chloe 404
11. Grace 405

A.2. Participants with Synaesthesia 407

12. Charlotte 407
13. Jack 409
14. Ethan 410
15. Thomas 412
16. Isabella 414
17. Ruby 415
18. Lily 417

A.3. Participants with Absolute Pitch or Quasi Absolute Pitch 419

19. William 419
20. Noah 420
21. Ava 421
22. Emily 423
23. Sophie 424
24. Joshua 425
25. Lucas 426
26. Liam 428
27. Zoe 429
28. Lachlan 430
29. Alexander 432
30. Max 433
31. Cooper 434
32. Henry 436
33. Sienna 437
34. Oliver 438
35. Amelia 439

A.4. A Tabulated Overview of the Demographic Details of all 35 Participants. 441

Appendix B. **442**

Appendix C. **443**

Appendix D. **444**

Appendix E. **449**

Appendix F. **461**

Appendix G. **462**

Appendix H. **467**

Appendix I. **468**

Appendix J. **470**

List of Figures

Figure 2.1. Graphic representation of the different forms of synaesthesia. 10
Figure 3.1. The implementation of the various data collecting stages. 69
Figure 3.2. Depiction of the qualitative focus of this mixed methods embedded design. 71
Figure 4.1. Two related aspects of grapheme→colour synaesthesia interact in music memorisation tasks in the case of Lily. 118
Figure 4.2. A pathway representation of how synesthetic percepts can aide intervallic thinking, in turn enhancing relative pitch (RP) abilities. 119
Figure 4.3. A representation of the functional difference between multimodal mental imagery (MMI), synaesthesia (as a specific form of MMI), and imagery-induced synaesthesia. 150
Figure 5.1. Percentage of overall participants who indicated the knowledge of their condition motivated them to commence formal musical training. 175
Figure 5.2. Percentage of overall participants who indicated the knowledge of their condition motivated them to pursue musical training at a tertiary level.... 176
Figure 5.3. The impact of synaesthesia and AP on intrinsic motivation and identity formation. …….. 219
Figure 7.1. Diagram showing the number of reported types of concurrent in sound-induced forms of synaesthesia..... 292
Figure 7.2. The multisensory representational system of Liam's absolute pitch (AP). 305
Figure 7.3a. Absolute pitch development during childhood or adolescence. 309
Figure 7.3b. Figure 7.3b. Bypassing of concurrent..... 309
Figure 8.1. A Cognitive-Affective-Behavioural (CAB) Model of Musical Development. 318
Figure 9.1. Kite formation modelling the experiential-cognitive-affective internal process, and behavioural external output. 357
Figure 9.2. The three steps to music processing within the EFM. 358

List of Tables

Table 3.1 *Distribution of preliminary responses to announcements made by the coordinator of Aural Studies 1 and 2 classes* 75
Table 3.2 *Distribution of final number of participants, noting their condition(s)* 76
Table 4.1 *Noah's 'sound bank', with songs or music situations he links to specific notes* 130
Table 4.2 *Overall responses to the question: "How vivid is your auditory imagery?"* 141
Table 4.3 *List of participants who reported experiencing complex visual imagery (CVI) in response to music* 168
Table 6.1 *Participant responses to the question as to whether their synaesthesia and/or AP facilitated specific music related tasks* 224
Table 6.2 *Participants were questioned as to whether their synaesthesia and/or AP hindered specific music related tasks* 225
Table 6.3 *A comparison of the total number of tasks reported as either being facilitated or hindered by synaesthesia or AP* 226
Table 7.1 *List of 11 participants with both conditions and their responses to four key questions concerning the dominance, interaction, and separability of synaesthesia and AP* 279
Table 7.2 *Prevalence of types of synaesthesia: list of the 35 types of synaesthesia reported by the 18 synesthete participants in this study* 288
Table 7.3 *List of the 10 types of sound-induced synaesthesia, with five types comprising ordinal sound sequences as inducer, and five types being induced by the perception of a non-ordinal sound stimulus* 289
Table 7.4 *Results of the two AP diagnostic tests (piano tones and pure tones) administered to participants in this study* 290
Table 7.5 *The number of overall cases of each type of concurrent, for all of the reported types of synaesthesia* 292
Table 7.6 *A tabulation of the 35 types of synaesthesia by concurrent type* 293

Chapter 1

Introduction

"The artist is, in a sense, a neuroscientist: exploring the potentials and capacities of the brain, though with different tools."

Semir Zeki (2016)

As a musician, I have always been fascinated by how the brain processes and reacts to music. For as long as I can remember, music has exerted an immediate and visceral grip on my emotional state. As someone who prizes rationality and logic, my youthful inability to regulate these music-induced emotions and adolescent realisation that I was unable to comprehend how music could exert such a powerful hold on me, was both intriguing and frustrating. As my ability to understand the structure and form of music matured, I became increasingly interested in the juxtaposition of the cognitive and affective influences of music. This curiosity became the foundation of my decision to study psychomusicology. My initial foray into the field was the publication of my Honours thesis, entitled: *The Neurology of Music: Music Lateralization and Amusia* (Eeltink, 2002). It was at this early stage of my research career that I was first exposed to discussions concerning 'synaesthesia': a neurological condition in which the stimulation of one sense modality leads to an automatic and involuntary experience in a second sense modality.

Synaesthesia was regularly mentioned in articles I read and lectures I attended over the coming years, particularly when discussing specific composers who reported having, or were believed to have, synaesthesia. These reports were almost exclusively anecdotal: synaesthesia was often spoken of with fascination, and yet was treated as a 'quirk' or eccentricity of little experiential importance. As such, the potential effects of the condition on musical perception, production, or development, remained unaddressed. That this condition was recurrently discussed piqued my curiosity, and I published my Masters mémoire under the title *La synesthésie équivoque d'Olivier Messiaen* ('The Ambiguous Synaesthesia of Olivier Messiaen'; Glasser, 2009), which examined the role of idiopathic synaesthesia on the compositional output of the illustrious French composer. To my knowledge, this was the first study of its kind to assess the potential role of synaesthesia as a neurological condition on compositional decision-making.

The research findings of my Masters mémoire led me to question how synaesthesia could impact the cognitive, affective, and behavioural outcomes of musical development. While the prevalence of synaesthesia has been established as higher among arts professionals and people involved in the creative industries (Ramachandran & Hubbard, 2001b; Rich, Bradshaw, & Mattingley, 2005; Rothen & Meier, 2010b), and while synaesthesia is linked to enhanced memory and creativity (Domino, 1989; Ramachandran & Hubbard, 2001b, 2003; Rich et al., 2005; Rothen, Meier, & Ward, 2012; Sitton & Pierce, 2004), I am aware of no studies that have examined the impact of music and sound-induced forms of synaesthesia on musical development. It is possible that this gap in current synaesthesia research might be

explained by music's inherent complexity, as well as the perceived difficulty of recruiting participants with a high level of music language competence.

What is more, my preliminary review of existing literature uncovered that a second neurological condition – 'absolute pitch' - was often mentioned as co-occurring with synaesthesia (Gregersen et al., 2013; Hänggi, Beeli, Oechslin, & Jäncke, 2008; J. Ward, Huckstep, & Tsakanikos, 2006). Absolute pitch (AP) is the ability to label a musical note without reference to any other note, and while the co-occurrence of certain types of music-induced synaesthesia and AP is indeed reported, any interaction between these two conditions remains highly speculative and lacking empirical foundation. The current study was therefore devised to compare the impact of synaesthesia and AP on musical development. It was also hoped that participants with both conditions would be located and recruited, with the aim of assessing the interaction of both conditions in musical contexts.

There are two key premises that frame this study: that the senses interact and do not operate in isolation, and that perceptual reality is subjective and constructed in the brain. Research in music psychology has largely focused on aspects of auditory perception, independently of the other senses. Yet the methodological assumption that one sense can be studied independently of the others is questioned by recent evidence suggesting that the senses and sense modalities interact and influence the information processing of other senses (Bremner, Lewkowicz, & Spence, 2012; Nanay, 2017; Spence, 2012; Spence & Chen, 2012; Stein, 2012). This study therefore examines the multisensory processing of music that synesthetes consciously experience, thus enhancing our understanding of the common rules that govern the interaction of the

senses. Furthermore, the brain is an information processing system, which takes in information from the senses, and interprets this information to construct individual multisensory realities. Thus, each of our distinct perceptual experiences of music is not only reliant on auditory input but is also heavily dependent on the interpretation of that input by our brains. Synesthetes (people who possess synaesthesia) and AP possessors perceive music in qualitatively different ways to others, and analysing these differences provides us with insights into the distinctiveness of each of our individual perceptions of music.

It has been proposed that "nature reveals herself through exceptions" (Cytowic & Eagleman, 2011, p. 246), and thus synaesthesia and AP are not simply 'fascinating' conditions; rather, they highlight the idiosyncrasy of each of our subjective perceptions of music. By studying the impact of synaesthesia and AP on musical development, this study seeks to provide a number of fresh insights into these two conditions, their interaction, and what they may reveal about musical development more globally.

1.1. Purpose of the Study

The major purpose of this study is to understand the unique musical experiences of synesthetes and AP possessors. Two research aims were formulated to address this purpose. The first research aim is to identify the degree to which synaesthesia or AP possession may facilitate or impair the cognitive, affective, and behavioural outcomes of musical development. The second aim is to investigate the potential interaction between synaesthesia and AP for participants who possess both conditions. The following research questions are therefore addressed:

1. Does the possession of synaesthesia and/or absolute pitch impact the cognitive, affective, and behavioural outcomes of musical development, and if so, to what extent?
2. For participants who possess both conditions, is there evidence to suggest they interact, and if so, in what ways?

To examine these two research aims, participants were questioned on the lived-world experiences of their conditions, in order to uncover new insights into the experiences of these individual musicians. This study expands knowledge within the fields of synaesthesia and AP research, by exploring the impact of synaesthesia and AP on participants' musical development, and of the complex relationship that exists between these two conditions and musical potential and ability.

1.2. Organisation of the Dissertation

This dissertation comprises nine chapters that are organised into three sections.

Section one provides the introductory framework for the dissertation. The current chapter (*Chapter 1: Introduction*) establishes the context of the study, identifies key gaps in our current knowledge, ascertains the research purpose, aims and questions, and provides an overview of the organisation of the dissertation. In *Chapter 2: Review of the Literature*, a review of the literature is provided. It is organised into three subsections: synaesthesia, absolute pitch, and literature that discusses both conditions simultaneously. Last, *Chapter 3: Design and Methodology* outlines the choice of method used, describes the sample, and details the measures and procedure employed in this study.

Section two presents the findings of the results obtained in this study across four chapters. In accordance with the two research aims proposed, the first three chapters present the results of the first aim of this study, and are therefore organised according to cognitive, affective, and behavioural outcomes. The final chapter of this section presents the results of the second aim of this study. The first results chapter, *Chapter 4: Cognition*, examines the cognitive outcomes of the possession of synaesthesia and AP. The impact of these two conditions on music memorisation and imagery is explored. *Chapter 5: Affect* examines the affective outcomes of the possession of synaesthesia and AP. This chapter assesses the impact of these two conditions on two interconnected domains: motivation and identity. The final results chapter of Aim 1, *Chapter 6: Behaviour*, assesses the behavioural outcomes of the possession of synaesthesia and AP. Two categories of behavioural outcomes are reviewed: musical choices and preferences, and music performance. To conclude this section, *Chapter 7: Synaesthesia and Absolute Pitch: Interactions and Comparisons*, investigates the relationship between synaesthesia and AP in participants who possess both conditions. A phenomenological comparison of synaesthesia and AP is also undertaken.

The third and final section summarises and comments on the analysis. *Chapter 8: Discussion* summarises the key findings of this study and provides a framework for the organisation of the results collected. Implications for research, individual musicians, and practice, are also specified. The final section of this chapter provides suggestions for future research. To complete this dissertation, *Chapter 9: Conclusion*

explains the significance of the study and proposes a model of musical development that elucidated the results and major findings.

Chapter 2

Review of the Literature

The literature to be reviewed is divided into three main areas: synaesthesia, absolute pitch (AP), and literature that treats both conditions simultaneously. In the first area, literature concerning synaesthesia as a neurological condition will be covered under five subheadings. The first two sections discuss the various forms, conditions, or conceptions that can be referred to as synaesthesia, and provide a detailed description of idiopathic synaesthesia, the form of most interest to the current study. The next two sections outline the history of synaesthesia research and discuss its prevalence. The last section deals with the relationship between synaesthesia and musical ability.

In the second area, literature concerning absolute pitch is surveyed according to four subheadings. As with the review of the literature concerning synaesthesia, the description, research history, and prevalence of absolute pitch are examined before a discussion of the relationship between absolute pitch and musical abilities.

The third and final section of this literature review examines the relationship between synaesthesia and absolute pitch and highlights the possible gaps that exist in this research domain.

2.1. Synaesthesia

2.1.1. Forms of Synaesthesia

The first necessary clarification concerns the problematic definition of the term 'synaesthesia', and with it its significations and categorisations. The term synaesthesia signifies different notions, realities, particularities, and perspectives to different people in different contexts. This ambiguity necessitates an explanation of the varying conditions or conceptions called synaesthesia.

As shown in Figure 2.1, there are five possible forms of synaesthesia:

1. Idiopathic synaesthesia.
2. Induced by a drug.
3. Induced by hallucinations resulting from epilepsy of the temporal lobes.
4. Induced by hallucinations caused by an elevated level of stress (hunger, cold, imprisonment, etc.).
5. Artificial synaesthesia, such as artistic metaphor.

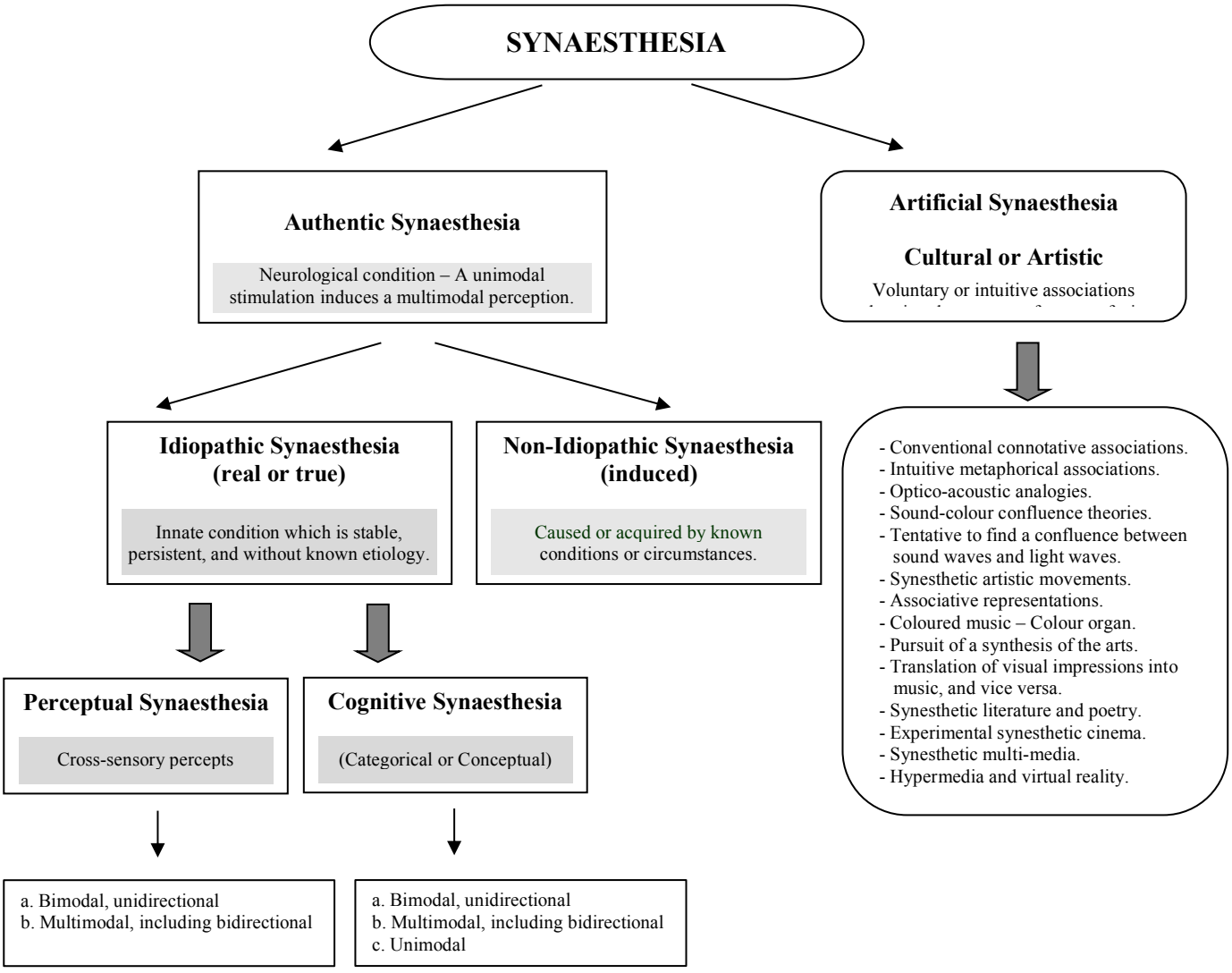

Figure 2.1. Graphic representation of the different forms of synaesthesia.

In the research literature, the first four forms of synaesthesia are classified as *authentic*, whereby the synesthetic percepts experienced by the synesthete are involuntary (Cytowic, 1989, 2002). In contrast, *artificial* synaesthesia, the fifth form, is characterised by deliberate associations (T. L. Hubbard, 1996). Authentic synaesthesia, which thus distinguishes itself from artificial synaesthesia, is the common name applied to two subdivisions:

I. *Idiopathic synaesthesia* (also called developmental, real, or true).

II. *Non-idiopathic synaesthesia* (also called induced or weak).

The first subdivision – idiopathic synaesthesia – is classified as innate or developmental, and is without etiology, lacking any known cause (Harrison, 2001). This first subdivision can equally be further divided into two subtypes:

a. Perceptual synaesthesia.
b. Cognitive synaesthesia.

This subsequent subdivision is described in the following section.

As this study examines the impact of synaesthesia on musical development across the lifespan of the participants in this study, cases of innate or developmental synaesthesia are examined. This literature review therefore concentrates on authentic, idiopathic synaesthesia as a real neurological condition, and details the latest scientific research and etiological hypotheses concerning this condition.

2.1.2. Definition of Synaesthesia

The word 'synaesthesia' (also spelt 'synesthesia') is derived from the Greek words *syn* (union or join) and *aesthesis* (sensation or perception): literally meaning joint perception, or a union of the senses (Cytowic, 1989, 2002). Synaesthesia is a rare neurological condition in which the stimulation of one sensory or cognitive pathway leads to an automatic, involuntary experience in a second sensory or cognitive pathway. As such, the stimulation of one sense modality automatically triggers a sensorial perception in another modality, and this in the absence of the direct stimulation of this second modality (Tager-Flusberg, 1999). Although it is referred to as a neurological condition, synaesthesia does not generally interfere with normal functioning, and this label is more a reflection of the neurological basis of the

perceptual differences that characterise synaesthesia, in a similar manner to absolute pitch or colour blindness.

People with synaesthesia are referred to as synesthetes, and the range and variety of their experiences is vast. For example, a synesthete may perceive numbers and letters as coloured (known as grapheme→colour synaesthesia), or perceive musical pitches as having distinct flavours (musical note→flavour synaesthesia). Learnt semantic categories such as letters, numbers, or days of the week are the most frequent stimuli, which then lead to sensory experiences such as the perception of synesthetic colour or flavour (Hochel & Milán, 2008).

The triggering stimulus is known as the *inducer*, while the resultant synesthetic experience is referred to as the *concurrent* (Grossenbacher, 1997). Therefore, with grapheme→colour synaesthesia as an example, each individual number or letter would be classified as the inducer, with the resulting colour perception being the concurrent. The directionality of the form of synaesthesia described is important, so to avoid the confusion that can arise from using ambiguous phrases such as 'coloured hearing', only the general and directional notated form of 'inducer (I)→concurrent (C) synaesthesia' will be used (Grossenbacher & Lovelace, 2001); in the case of what is typically referred to as 'coloured hearing', this would be notated as sound→colour synaesthesia, whereby (as the arrow indicates) sound induces colour.

2.1.2.1. Perceptual and cognitive types of synaesthesia.

It is important to note from the outset that while the inducer and concurrent often

belong to different sense modalities, such as in sound→colour synaesthesia (auditory→visual), and therefore seem to be truly cross-sensory, this is not always the case (Simner, 2012). As such, a common misrepresentation of synaesthesia as a "union of the senses" is not always technically true. This misconception may date back to the previously mentioned Greek etymology of the word, but from what is now known about the wide variety of possible synesthetic experiences, describing the condition in purely sensory-perceptual terms would be to exclude many of the most prevalent forms of synaesthesia. The combination of different modal qualities within the same sense is also classifiable as synaesthesia, such as in the common form of grapheme→colour synaesthesia, where 'visual' colours are induced by 'visual' letters or numbers. In this example, the inducer (grapheme) is a high-order cognitive construct, which is involved in language comprehension and production (Simner, 2012).

There appears to be two distinct types of idiopathic synaesthesia: *perceptual synaesthesia* describes perceptions in which the inducers are sensory stimuli (such as music), while in *cognitive synaesthesia* the concurrents are induced by perceiving particular concepts (such as numbers) (Grossenbacher & Lovelace, 2001; Robertson & Sagiv, 2005). Questions arise however, as to the exact role of high-order cognition in the synesthetic inducers. For synesthetes who experience, for example, coloured percepts from letters and numbers, it is necessary to ascertain whether the colour percepts are triggered in response to the form of the grapheme itself, or rather by linguistic processing. One way of addressing this distinction in more detail is to examine grapheme→colour synaesthesia. There are two ways that a synesthete may process each grapheme. The first would be to process the written form of the letter

itself, whereby the perceived colour percept would be font and case sensitive. In this instance, an '*a'* would have a colour distinct from an 'A'. If this were the case, the particular form of synaesthesia would be sensory/perceptual and triggered by the visual curvatures and lines of the written form of the grapheme (Simner, 2012). This is in contrast to the second possible way of processing the grapheme, whereby all the possible distinct visual forms of each individual grapheme trigger the same colour percepts. In this instance, and using the above example, an '*a*' would induce the same colour as an 'A' because of the associated linguistic category that the two letters share.

Initial studies undertaken to address this question have observed that although there are documented exceptions, it does appear that the majority of grapheme→colour synesthetes are insensitive to variations of the form of individual graphemes, and are therefore processing the linguistic function of the grapheme (Grossenbacher & Lovelace, 2001; Smilek, Dixon, Cudahy, & Merikle, 2002). The small proportion of the synesthetic population that have been found to be sensitive to the visual form of the graphemes have been coined 'lower synesthetes', while the resulting majority have been named 'higher synesthetes' in reference to their conceptually driven concurrent percepts (E. M. Hubbard, Arman, Ramachandran, & Boynton, 2005; E. M. Hubbard & Ramachandran, 2005).

Further evidence of the conceptual process underlying the perception of synesthetic colours in relation to graphemes is found in studies that have investigated ambiguous symbols, such as '1' (Dixon, Smilek, Duffy, Zanna, & Merikle, 2006; Myles, Dixon, Smilek, & Merikle, 2003). It was found that the same ambiguous symbol could trigger

different synesthetic colour percepts depending on the context into which it was placed. As such, the colour of the symbol was reliant on the letter or number category into which it was placed, and consequently the '1' of '12345' (where it would be perceived as being the first in a series on numbers) would be perceived differently to the '1' of '1mnop' (where it would be perceived as being the first in a series of letters). In the majority of cases, it is therefore the conceptual and not perceptual features of the given inducer that trigger the appropriate concurrent.

Synaesthesia is therefore not purely sensory or perceptual. However, it is important to understand that that the above-described dichotomy of perception is a simplification of the experiences of many synesthetes. It has been suggested that, even for higher synesthetes, the visual form of the grapheme may have in certain cases a slight influence on the concurrent colour percepts. In this instance, although the same letter or number would trigger the same general colour, regardless of its font or case, there may be a subtle difference between the exact hue perceived, with one being more luminous or saturated than the other (Ramachandran & Hubbard, 2003; Witthoft & Winawer, 2006). Studies of synaesthesia generally ask synesthetes to name their perceived colour percepts, which may lead to certain synesthetes describing different manifestations of the same grapheme as 'blue', for example, even if the exact shade of 'blue' is not the same. Therefore, although there are documented cases where visual characteristics have been shown to influence colour percepts, it is unclear whether this is a typical phenomenon, or limited in scope (Ramachandran & Hubbard, 2003; Simner, 2012; Witthoft & Winawer, 2006).

In addition, perceptual factors may play a role in otherwise conceptual forms of

synaesthesia, as in the case of higher synesthetes. Several studies have recently demonstrated that letters and numbers that are similar in shape (such as 'E' and '3') may be closer in colour to those that differ in shape (Eagleman, 2010; C. Mills et al., 2002; Witthoft & Winawer, 2006). However, what remains unclear is the developmental stage within which this influence occurs. It has been suggested that the visual form may not play any role in the actual triggering of the synesthetic percept, but rather that the application of a colour to similarly shaped graphemes may occur at an early stage of development, and during the initial establishment of the synesthetic percepts (in this case colours) (Simner, 2012). Once these initial connections are formed, and the pairing of individual graphemes to individual colours has been firmly established (based on perceptual features), the synesthetic experience may become largely insensitive to low-level visual features such as font and case, and is instead triggered by the conceptual category of the grapheme (Simner, 2012).

Throughout this description the focus has been on one – albeit the most common – form of synaesthesia: grapheme→colour. However this description is not type-specific, and is compatible with all applicable forms of synaesthesia (see, for example, Simner & Haywood, 2009; Simner & Ward, 2006). It is also notable that the synesthetic concurrent may, in the same way as the inducer, involve cognitive constructs. 'Ordinal linguistic personification', or OLP (in which linguistic sequences, such as graphemes or units of time, induce impressions of gender or personality type), is an excellent example of this. One such example given by a synesthete is of the letter 'a' being a busy mother, while the number '9' is a devoted husband (related in Flournoy, 1893; Simner & Holenstein, 2007; Simner & Hubbard, 2006; Smilek et al., 2007). Once again, the notion of synaesthesia as a union of the senses is a

misrepresentation of the often-cognitive influences on both the inducer and the concurrent.

2.1.2.2. Unimodal, bimodal, and multimodal forms of synaesthesia.

In cognitive synaesthesia, there is the possibility that certain forms of synaesthesia may be *unimodal*, that is, that both the inducer and the concurrent belong to the same sense (such as in grapheme→colour synaesthesia, as we have previously established). But there are also two other sub-classifications that can be applied to both perceptual and cognitive synaesthesia: *bimodal* and *multimodal* forms (see Figure 2.1).

Bimodal synaesthesia is a unidirectional crossing of two sensory or cognitive pathways (for example, auditive→visual, but not the inverse). As we have five senses (visual, auditive, tactile, gustative, and olfactive), there are ten possible pairs, and working in either direction, this leaves us with 20 possible base combinations. Added to these combinations are other sensory modalities such as temperature, pain, emotions, and movement, to name just a few, as well as cognitive modalities such as symbols and personification. This leaves us with a wide variety of different potential pairings.

Multimodal synaesthesia is the term used to describe the crossing of three or more sensory or cognitive pathways (for example, when specific musical sounds induce not only colours, but odours as well for the same synesthete). In rare multimodal cases, synesthetes can experience truly eclectic sensorial experiences. Note also that all bidirectional forms of synaesthesia (such as when musical tones not only induce colours, but inversely when colours induce musical tones for the same synesthete) are

classified as types of multimodal synaesthesia. Bidirectional synaesthesia is equally a very rare occurrence (Schönenberger & Burela, 2007).

2.1.3. Diagnosing Idiopathic Synaesthesia

Historically, diagnosing synaesthesia has met with several challenges (Simner, 2012). First, the term 'synaesthesia' has been, and continues to be, applied to a wide variety of phenomena (Berman, 1999; Cytowic, 1989; Day, 2005; Mulvenna, 2007). This impreciseness in the utilisation of the term, from synesthetic artistic movements, to drug-induced hallucinogenic states, and real synesthetic perceptions, has often led to confusion concerning the exact nature of idiopathic synaesthesia. Furthermore, no two synesthetes' associations are identical: while one synesthete may experience the colour red on hearing a C played on the piano, a second synesthete may experience the colour blue, and yet a third yellow (Dixon & Smilek, 2005; E. M. Hubbard et al., 2005). This being said, certain studies have observed that there are discernible trends concerning certain stimuli. For example, Day (2005) observed that almost two-thirds of grapheme→colour synesthetes perceived the letter 'O' as white. The idiosyncratic nature of synesthetic mappings is not the only discrepancy apparent in descriptions of the synesthetic experience. When asked where they experience their concurrent synesthetic percepts, different synesthetes indicate diverse spatial locations. For example, while one musical tone→colour synesthete may indicate perceiving their colour percepts as 'with their mind's eye', 'interiorly', or 'intellectually', in a manner very similar to mental imagery, another will speak of their percepts as being 'projected' externally, and often onto or surrounding the synesthetic inducer (Dixon, Smilek, & Merikle, 2004). A classic example of this is in the case of coloured 'auras' surrounding people or objects in personality→colour synaesthesia. The subjective

nature of synaesthesia and its idiosyncrasy make it difficult to place within general scientific taxonomy (Hochel & Milán, 2008). Despite this apparent phenomenal heterogeneity, an initial series of diagnostic criteria was established by Cytowic in 1989, and has since been further revised to incorporate changes in our understanding of the synesthetic phenomenon (Cytowic, 1989, 1993, 2002). These five diagnostic criteria (2002) categorise synaesthesia as:

1. Involuntary and automatic.
2. Consistent and generic.
3. Spatially extended.
4. Memorable.
5. Affect-laden.

While there are five diagnostic criteria indicated above, it is the first two criteria that are the most widely accepted within the scientific community and the least problematic, as they describe and define the essential features of the synesthetic phenomenon (Hochel & Milán, 2008; Simner, 2012). The remaining three criteria may not be 'diagnostic' in the strictest sense of word, but are more likely to represent characteristics that are observed to a higher or lesser degree in the overwhelming majority of cases of synaesthesia, without necessarily being present in every case (Hochel & Milán, 2008). With this in mind, a closer examination of these diagnostic criteria is necessary, with a particular focus on the first two.

2.1.3.1. Synaesthesia is involuntary and automatic.

The involuntary nature of synaesthesia means that it cannot be either suppressed nor evoked as desired by the synesthete, and seems to be immune to any voluntary control

on the part of the synesthete (Dixon, Smilek, Cudahy, & Merikle, 2000; Mattingley, Rich, Yelland, & Bradshaw, 2001; Wollen & Ruggiero, 1983). For a synesthete with musical note→colour synaesthesia, the colour percept will appear simultaneously and automatically at the sound of the note in question. This colour percept will only cease at the elimination of the inducer (in this case, the musical note). The intensity of the percept can vary depending on the situation that the synesthete may be in, or on the synesthete's level of attention.

2.1.3.2. Synesthetic percepts are consistent and generic.

While there have been rare reports of synaesthesia only becoming apparent to the synesthete from the onset of puberty, in the majority of reported cases synesthetes describe that the memory of their synesthetic percepts goes back as far as they can remember (Cytowic, 1993; Cytowic & Eagleman, 2011). This suggests that synaesthesia is acquired in the early stages of development, and typically lasts for a lifetime, although synesthetic capacity has been known to be lost as a consequence of cerebral trauma (see Farina, Mitchell, & Roche, 2017; Sacks, Wasserman, Zeki, & Siegel, 1988; Spalding & Zangwill, 1950). There are, however, no known cases of the spontaneous remission of synaesthesia. Once initially established during early childhood, the idiosyncratic associations of each synesthete are durable and consistent, remaining unchanged throughout the lifetime of the synesthete (the same inducer will always trigger the same concurrent).

To test the consistency of synesthetic percepts, test-retest studies have asked synesthetes to name their synesthetic associations over periods of several months or even years. It has been demonstrated that when both synesthete and non-synesthete

participants are asked to associate colours with the same inducers, the responses of non-synesthete participants – even if tested over considerably shorter periods of time - are far less accurate than those of synesthetes (Eagleman, Kagan, Nelson, Sagaram, & Sarma, 2007). One example of this can be found in the study of a spoken language→colour synesthete whose responses during a retest 10 weeks after the initial test revealed a 100% consistency score with respect to the previous experimental session (Baron-Cohen, Wyke, & Binnie, 1987). This was in contrast to the control participant's score of 17% consistency after a test-retest period of less than two weeks. What this demonstrates is the stability of the connection between the inducing stimuli and the concurrent synesthetic response. Further studies carried out using this methodology have also reported consistency levels at, or near to, 100% (Dixon et al., 2000; Mattingley et al., 2001). Even after a control period of several months, this stability has been shown to remain consistent (Baron-Cohen, Harrison, Goldstein, & Wyke, 1993). Recently, similar but more sophisticated tests have been devised using software colour palettes, which allow researchers to more precisely match the colours of the photisms indicated by the synesthete (Milán et al., 2007; Witthoft & Winawer, 2006).

The absolute level of consistency of synesthetic percepts, however, has recently been challenged. One study reported that 17% of participants experienced modulations of their synesthetic experiences such as changes of the concurrent color, expansion within the same or to a different sensory modality, or reduction of the number of inducers over time (Niccolai, Jennes, Stoerig, & Van Leeuwen, 2012). Not only is the presumed consistency of synaesthesia questioned in this study, but also the adequacy of the test-retest score to assess its authenticity in a self-referred synesthete.

The second concept iterated within this diagnostic criterion is that the synesthetic percepts are generic and limited, in the sense that they are not elaborate or pictorial (Cytowic, 1989). Synesthetic percepts generally correspond to basic perceptual qualities – often coloured - such as lines, spirals, blocks, grills, or geometric forms. They may also correspond to elementary qualities such as temperature variants (hot, cold), or taste variants (sweet, salty, sour, etc.) to name just a few. This aspect, in addition to its consistency and durability, sets synaesthesia apart from other phenomena such as psychotic hallucinations (Hochel & Milán, 2008).

2.1.3.3. Synesthetic percepts are spatially extended.

2.1.3.3.1. Projector and associator synesthetes.

Synesthetes may experience their synesthetic percepts in two qualitatively distinct ways, with synesthetes being categorised into two main groups (Dixon et al., 2004). The first are known as *projector* synesthetes, and they report experiencing their percepts externally, in the peripersonal space immediately surrounding their bodies, or on a screen directly in front of their faces (Schönenberger & Burela, 2007). This type of representation may also extend to the inducer, whereby for example the colour may be projected onto a printed grapheme in the case of grapheme→colour synaesthesia. Sometimes, the concurrent is literally felt on the skin. One of the most well-known case studies, which was partly the catalyst for the renaissance of the interest in synaesthesia, was of a gustatory→tactile synesthete who felt shapes in his hands in response to tastes. The synesthete described how he would change the position of his hands to better reach for the 3-dimensional shape that he could feel, thus illustrating

the spatial quality of his synesthetic percepts (Cytowic, 1993). This form of exterior representation is not, however, the only possible synesthetic manifestation.

In contrast, the second category is less obviously spatially extended. A secondary group of synesthetes describe experiencing their synesthetic percepts (often visual) with their 'mind's eye', or interiorly. These synesthetes are known as *associator* synesthetes (Dixon et al., 2004). While this may seem closely similar to visual imagery, the synesthetic percepts described by this category of synesthetes remain automatic and involuntary, as with projector synesthetes.

While the subjective reports of these two categories of synesthetes are different, there are also noticeable differences during experimental tests. One study used a modified Stroop task with both self-reporting projector and associator synesthete participants, who were asked to undertake two tasks (after having provided their unique grapheme→colour associations): the first task was to name the colour of a grapheme which was presented to them on a screen, while the second task was to name the colour of the photism triggered by the given grapheme (Dixon et al., 2004). In both tasks the colour of the grapheme was either shown in a congruent or incongruent colour in relation to the individual synesthetes' specified colour associations. What these tests clearly showed was that projector synesthetes found it harder to name the colour of the presented grapheme than it was to name their synesthetic colour percepts. That is, their projected colour percepts seemingly interfered with their ability to name (or 'see') the real colour of the grapheme, whereas the real colour of the grapheme did little to interfere with their projected photisms. In contrast, associator synesthetes showed the same level of interference in both tasks and were

also faster at naming the real colour of the grapheme, indicating that their photisms were less of an interference than they were for the projector synesthetes.

The interference pattern established by Dixon and colleagues (2004) was also reported in a separate study (J. Ward, Li, Salih, & Sagiv, 2007), however according to Ward and colleagues, the reason behind this behavioural discrepancy lies in the possibility that these two synesthete categories employ differing spatial frames of reference regarding their synesthetic percepts. The frame of reference of projector synesthetes is externalised and defined relative to the location of the inducing grapheme, whereas the frame of reference for associator synesthetes in internalised. Ward and colleagues came to the conclusion that the slower reaction time of the associator synesthetes in naming their colour percepts during this task was due to an attentional effect. What was suggested was that associator synesthetes would need to shift their attention from one spatial location (the grapheme) to a second location (their internalised colour percept), whereas the attention of a projector synesthete would remain constant and in one location during the task.

2.1.3.3.2. Lower and higher synesthetes.

The distinction between projector and associator synesthetes may be driven by differing levels of representation of the inducing stimulus. For this reason, there has been a proposed alternative to the above-mentioned labels of projector and associator. Synesthetes for whom their synesthetic percepts are elicited by specific perceptual features of the inducer, such as the form of a grapheme, have been termed as *lower* synesthetes, while for synesthetes for whom their percepts arise in response to more abstract or conceptual aspects of the inducer, such as the meaning of a number, have

been termed as *higher* synesthetes (E. M. Hubbard & Ramachandran, 2005; Ramachandran & Hubbard, 2001b, 2003). It is probable that the percepts of lower synesthetes occur during the early stages of perceptual processing, while different brain areas process those of higher synesthetes. It is unclear however whether this dimension is indeed dichotomous as so described, or whether this classification is misrepresenting a continuum running from lower to higher synaesthesia (Hochel & Milán, 2008). Furthermore, Ward and colleagues (2007) have argued that the distinction proposed by Ramachandran and Hubbard may be more problematic than the associator/projector distinction proposed by Dixon and colleagues (2004), as the higher/lower distinction is founded on theoretical assumptions rather than on reports of synesthetes themselves (J. Ward et al., 2007). While it was speculated that it may have been possible to map both pairings onto each other (Dixon & Smilek, 2005; E. M. Hubbard & Ramachandran, 2005), Ward and colleagues (2007) indicated that the personal accounts of synesthetes themselves demonstrate that the presence or absence of lower or higher characteristics is independent of the projector/associator classification.

2.1.3.4. Synaesthesia is memorable.

The synesthetic percepts experienced by the synesthete are easily and clearly remembered – often better than, or even in place of the initial stimuli (Cytowic, 1993; Cytowic & Eagleman, 2011). A synesthete with spoken word→colour synaesthesia, for example, may remember the colour of the name of somebody they were just introduced to, rather than the name itself. There also exists a strong association between synaesthesia and eidetic or photographic memory, while many synesthetes report using their synaesthesia as a mnemonic device (Niccolai et al., 2012). These

additional memory cues have been shown to enhance a synesthete's memory when the task is in relation to their specific form of synaesthesia (Rothen et al., 2012). For example, a synesthete with grapheme→colour synaesthesia may be able to use the colours associated with specific numbers as a mnemonic device when memorising and remembering telephone numbers (for a discussion of the association that exists between synaesthesia and memory, see Section 2.1.6.1.: 'Synaesthesia and memory', below).

2.1.3.5. Synaesthesia is affect-laden.

The relationship between synaesthesia and emotion has been emphasised during several studies (Cytowic, 2002; Milán et al., 2007; Ramachandran & Hubbard, 2001b; J. Ward, 2004). For synesthetes, a feeling of certitude and a conviction of the reality and validity of its existence accompany their synaesthesia (Cytowic, 1989). Tasks that relate to their synesthetic percepts may be highly emotionally charged, either in an agreeable or disagreeable way. Synesthetes frequently claim that they have experienced 'Eureka!' moments when their synesthetic percepts are satisfied by matching external conditions (Cytowic, 2002). Inversely, if their synesthetic percepts are incongruent with the outer reality, then they can be associated with disagreeable or negative feelings. This may be true for a music→colour synesthete who watches a live performance during which coloured lights are projected onto the stage. If the coloured lights match the synesthetes colour percepts (which have been triggered by the music) then the synesthete may experience what has been described as a feeling of ecstasy (Cytowic, 1989). If, on the other hand, the real projected colours do not match the synesthetes colour percepts, then that same synesthete may experience a feeling of disgust, or even experience a negative physical reaction.

Certain types of synaesthesia are directly related to emotion (Hochel & Milán, 2008). Once such example is when synesthetic colours are experienced in response to faces, human figures, or visual scenes when these visual stimuli have an emotional content. Milán and colleagues (2007) reported the case of a synesthete whose colour percepts were triggered by his emotional assessment of the person or visual stimulus. Interestingly, this synesthete often used his percepts to refine his opinion of the person or object in question, although on rare occasions the colour percept he experienced was incongruent with his personal feelings for the person or object. This incoherent matching between the negative colour percept and his positive reaction towards the person or object was extremely uncomfortable for him and led to further negative emotions. A similar case, describing a synesthete who experiences synesthetic colour percepts in response to faces, the names of familiar people, and affect-laden words, was reported by J. Ward (2004).

2.1.3.6. Key points.

These five diagnostic criteria mentioned above define idiopathic synaesthesia and differentiate it from all forms of induced synaesthesia, whether they be caused by neuronal degeneration, cerebral lesion, spinal cord lesion, environmental conditions such as elevated levels of stress, through the consummation of certain hallucinogenic drugs such as LSD or mescaline, or by learnt associations.

2.1.4. History of Synaesthesia Research

In a landmark study, Georg Sachs (1812) reported the earliest known medical account of synaesthesia. Sachs described his own synaesthesia as part of his doctoral research

into his albinism, and that of his sister (Dann, 1998; Jewanski, 2013; Jewanski, Day, & Ward, 2009). While the original PhD manuscript was written in Latin, a German translation became available just over a decade later. This case study was widely cited in the medical literature of the nineteenth century, but was less well known to contemporary researchers until an English translation of the sections concerning synaesthesia was made available (Jewanski et al., 2009). Following Sachs, several reported cases of possible synaesthesia were published, but these failed to incite mainstream interest until Francis Galton published a series of observations regarding synesthetes in 1880, almost 70 years after Sachs' initial publication (Galton, 1880a, 1880b). He noted that a rare group of people had the capacity to experience the stimulation of one sense in a multimodal way (Ramachandran & Hubbard, 2001b). The articles published by Galton in *Nature* (1880a, 1880b) on the subject of synaesthesia focused on the three most common synesthetic manifestations: grapheme→colour, sequence space, and sound→colour synaesthesia. This publication brought synaesthesia to the forefront of scientific interest, and by the end of the nineteenth century, certain types of synaesthesia (and in particular sound→colour, and music→colour synaesthesia) were so popular as a subject of scientific discussion that a committee of psychologists was organised at the 1890 *International Congress of Physiological Psychology*, to standardise the terminology used to describe synaesthesia, and to advance the scientific understanding of the condition (Marks, 1975). This interest in the synesthetic phenomenon led to several studies on the condition during the early years of the twentieth century. Other case studies were published, and by the 1910s there were over 50 published articles on sound→colour synaesthesia alone, many by some of the most reputable psychologists of the times.

That synaesthesia had the occasion to become one of the dominant themes of discussion during the latter part of the nineteenth century is understandable in light of the general context of the times. This was a period of time when the general public became fascinated by the phenomenon, with the French in particular adopting the notion of synaesthesia as the foundation for an artistic movement that would produce such works as Arthur Rimbaud's poem *Voyelles* (1871), based on a contrived set of associations between vowels and colours. At the same time, there existed a growing number of scientists looking for opportunities to discredit the theological notion of the soul, and to interpret and explain all spiritual mysteries entirely by psychological stipulations (Cytowic, 1993). The emergence of this new artistic movement would, to a certain extent, keep to this essential interpretation.

The end of the nineteenth century, and the beginning of the twentieth century, brought with them the rapid development of psychology and psychoanalysis. Hence after this initial surge, interest into the synesthetic phenomenon declined rapidly (E. M. Hubbard, 2005), in line with the gradual onset of behaviourism in the 1930s.

From the mid-1930s there was a considerable reduction in the psychological literature on synaesthesia. The problem that researchers faced was that synaesthesia is an internal, subjective experience, with the majority of studies of the time focusing and relying on reports given by the synesthetes themselves. The school of behaviourism rejected this form of study in the 1920s and 1930s, while the idiosyncratic nature of the phenomenon, as well as the mistrust of the scientists of the time towards subjective experiences, placed synaesthesia out of the scope of general scientific interest. As a result of the lack of medical and psychological information available

during this time concerning synaesthesia, many synesthetes were misdiagnosed as schizophrenics or drug addicts, or were even confined to mental institutions (Day, 2005). At best, medical professionals of the day were skeptical of the validity of the synesthetic symptoms, considering the synesthete as being excessively metaphorical in their descriptions (Cytowic, 1993).

While several landmark publications appeared in the following decades, they received little attention, and were viewed more as curiosities than as strong scientific investigations. One of the most interesting of these studies described the case of eidetic memory in a multimodal synesthete with multiple forms of synaesthesia (Luria, 1968/2006). The following decade brought with it the publication of a book entitled *The Unity of the Senses*, by Lawrence Marks (1978). Here, Marks outlined the importance of the synesthetic phenomenon, and emphasised its potential for studying the neurological basis of metaphor. Nonetheless, at the time of its publication, this invitation would rest on deaf ears, as the still dominant influence of behaviourism would reject the notion of examining a phenomenon that could only be exposed through first-person verbal reports. To behaviourists, the collecting of empirical data necessitated the elimination of the subjective role of a human observer (Cytowic, 2002).

It was not until the 1980s, when behaviourism was supplanted by cognitivism, that there was a ‘renaissance’ of interest in synaesthesia, and it was once again placed at the forefront of empirical scientific research (Cytowic, 1989; Cytowic & Eagleman, 2011). This transformed landscape was instigated by a number of contemporary researchers who demonstrated that the existence of synaesthesia could be empirically

validated through psychometric testing methods (Hochel & Milán, 2008). In addition to these testing methods, scientists now have the opportunity to use modern neuroimaging techniques to study the brains of synesthetes (for a review of studies that have used these techniques, see E. M. Hubbard & Ramachandran, 2005).

That synaesthesia is the outcome of a cerebral process, in the same way as normal sensation, has now been firmly established. This was made possible when scientists acquired the capacity to study the brain's regional metabolism during specific cognitive behaviour. The results of these studies on metabolic changes during a synesthetic episode demonstrate that this rare phenomenon is indeed cerebral (perceptual), and not based on thought processes (imagination) (Cytowic, 1989). Studies undertaken by Cytowic in 1985 (and subsequently published in 1989) confirmed and reinforced the theoretical notion that synaesthesia is not a semantically mediated intermodal association, but rather a material phenomenon which implies the relative suppression of cortical activity (Cytowic, 1989).

2.1.5. Prevalence

Idiopathic synaesthesia is a relatively rare condition. Estimates concerning the prevalence of synaesthesia vary widely, with modern studies estimating ranges from as low as 1 in 25,000-100,000 (Cytowic, 1993, 1997), to 1 in 2000 (Baron-Cohen, Burt, Smith-Laittan, Harrison, & Bolton, 1996), and to 1 in 200 (Ramachandran & Hubbard, 2001a) in studies based on self-referral. Why this level of variation occurs is two-fold. First, different studies have used different definitional criteria for synaesthesia, and second, certain studies have focused primarily on differing subtypes of synaesthesia (Simner, Mulvenna, et al., 2006). More recently, the first random

sampling study on the condition estimated synaesthesia to occur in as high as 4.4% of the population (Simner, Mulvenna, et al., 2006).

2.1.5.1. Prevalence and gender.

Analogously, earlier studies reported an apparent female bias in the synesthetic population, with ranges from 2:1 (J. Ward & Simner, 2005) to approximately 6:1 (Baron-Cohen et al., 1996; Rich et al., 2005). These last two studies requested synesthetes to respondent to a newspaper advertisement, and then obtained their estimates on the prevalence of synaesthesia within the general population by dividing the newspapers' circulation figures by the number of respondents. Nevertheless, as these studies relied on self-referral, the claim that non-respondents were not synesthetes is untenable.

These shortcomings were addressed in a recent study that individually assessed a large population sample on two separate occasions (Simner, Mulvenna, et al., 2006). The participants were individually assessed and tested with objective tests of genuineness to measure the consistency over time of their percepts. For this study, an initial sample was drawn from the population of the Universities of Edinburgh and Glasgow (n = 500), while a second sample was from visitors to London's Science Museum (n = 1190). For the Universities sample, the study identified 22 synesthetes (a prevalence of 4.4%) and showed no significant sex bias, with a female to male ratio of 1.1:1. While the Universities study tested for all known types of synaesthesia, the Museum study only tested for grapheme→colour synaesthesia and identified 13 grapheme→colour synesthetes (a prevalence of 1.1%). For the purpose of a cross-population comparison, the prevalence of this particular type of synaesthesia was also

tabulated in the Universities study and was found to have a prevalence of 1.4%. Similar to the Universities study, the Museum study showed no significant sex bias, with a female:male ratio of 0.9:1.

The extreme female dominance of the before mentioned Baron-Cohen and colleagues (1996) and Rich and colleagues (2005) studies was not supported in the Simner and colleagues (2006) study. This female dominance is likely to have arisen as a reporting confound, where male synesthetes are less likely to report their atypical experiences, as has been demonstrated in other areas of self-referral (Dindia & Allen, 1992). The absence of a female bias may also undermine previous arguments for X-linked dominant inheritance, although this rests a contentious issue that is far from being resolved. This possibility was first suggested by Baron-Cohen and colleagues (1996). As there was no evidence of father to son transmission in their results, while all other possible parent to offspring patterns of transmission were observed, it was speculated that a single dominant gene inherited via the X chromosome could result in synaesthesia. However, while this lack of evidence of father to son transmission is apparent, it is difficult to ensure that the trait is not present in both paternal and maternal lines during genealogy studies of synesthetes' families (J. Ward & Simner, 2005). Because of the previously noted high female:male ratio (6:1) indicated by this study, it was postulated that the trait may be lethal in males, leading to a high level of miscarriages. This claim was supported by the fact that the families of the synesthetes in this study contained more women than men (Baron-Cohen et al., 1996). While it has been stressed that great care should be taken on this point, what remains clear is that instances of father-to-son transmission are often absent from case-studies, and remain extremely hard to find, thus supporting an X-linked hypothesis (Simner,

Mulvenna, et al., 2006).

2.1.5.2. Prevalence of different forms of synaesthesia.

There are currently over 60 documented forms of synaesthesia, with the most prevalent form being grapheme→colour synaesthesia. In fact, it has been demonstrated that between 82-88% of all forms of synaesthesia are triggered by language units such as graphemes, phonemes, and words (Niccolai et al., 2012; Simner, Glover, & Mowat, 2006; Simner, Mulvenna, et al., 2006). The second most prevalent form is spatial-sequence synaesthesia, whereby time related words are perceived in a spatial location, and this has been found to occur in up to 62% of cases (Niccolai et al., 2012). The most prevalent music inducing form is music→colour synaesthesia, in which a musical stimulus (the inducer) elicits a colour perception (the concurrent). This type of truly cross-modal linking is often considered a paradigmatic example of synaesthesia, even though it is less common than other types. Estimations on the prevalence of music→colour synaesthesia within the synesthete population vary between studies, being reported at 41% in a recent study by Niccolai and colleagues (2012), which is higher than the 25% and 18.7% reported by Rich et al. (2005) and Barnett et al. (2008), respectively. Sound→colour synaesthesia (non-musical) is also quite common, and has been found to occur in 33% of synesthetic occurrences (Niccolai et al., 2012). As becomes obvious with these figures, it is very common for synesthetes to experience two or more types of synaesthesia, and it has been established that this is true for 81% of the synesthetic population (Niccolai et al., 2012).

2.1.6. Synaesthesia and Musical Ability

In addition to the prevalence of synaesthesia within the general population, the reported high incidence of synaesthesia among artistic professionals and people with creative hobbies is an additional demographical aspect that was recently confirmed in the previously mentioned large-scale study by Rich and colleagues (2005). This study established that 24% of the synesthetes questioned were professionally engaged in the arts, in comparison to a general population rate of only 2% (Hochel & Milán, 2008). Other studies have also shown similar results (Cytowic, 1989; Domino, 1989; Niccolai et al., 2012; Ramachandran & Hubbard, 2001b). A study of arts students found that 7% of the sample were synesthetes, compared to 2% of the control sample (Rothen & Meier, 2010b), suggesting that synaesthesia may be more prevalent in arts students, thus tying in with previous research into the higher prevalence of arts professionals within the synesthete population. These studies have led to suggestions as to the possible links between synaesthesia, metaphor, creativity, and the origins of language (Domino, 1989; Ramachandran & Hubbard, 2001b; Sitton & Pierce, 2004). Apart from professional engagement, Niccolai and colleagues (2012) further indicated that 68% of the respondents in their study were artistically active, and an interest in the arts was frequently reported. Moreover, 78% of participants indicated that their synaesthesia was an advantage in creative jobs, memorising, learning, or calculating. Participants further described themselves as skilled at painting, learning, foreign languages, and memorisation. On the contrary, participants in the same study reported poor abilities in mathematics, tasks involving sustained concentration, spatial imagination, and spatial perception.

While the best known and most widely studied form is grapheme→colour

synaesthesia, less research has explored the neuroanatomical basis of other forms, including music→colour synaesthesia (but see Zamm, Schlaug, Eagleman, & Loui, 2013). Recently, data collected by neuro-imaging techniques employed during the synesthetic experience clearly validate idiopathic synaesthesia as a real phenomenon and differentiates it from imaginative mental imagery. This validation has led interdisciplinary research to debate whether idiopathic synaesthesia can actively contribute to an artist's ability, and whether synaesthesia can be understood as a motivational force for the synesthetic artist. This distinction of the synesthete brain may prove to be a window into a neural basis of creative cognition, which may in turn prove conductive to various forms of creative expression (Mulvenna, 2007).

2.1.6.1. Synaesthesia and memory.

Research is yet to elucidate exactly why and where the memory advantage lies, yet evidence suggests that in certain instances synesthetes do indeed have an advantage (see Rothen et al., 2012 for a review of the current literature). In one recent study, 19% of synesthete participants reported having a photographic memory (Niccolai et al., 2012). This result corresponds with previous studies on memory performance in synaesthesia. One of the most striking examples of extraordinary memory performance of a synesthete was a study of Shereshevskii undertaken by Luria in 1968. Not only could Shereshevskii remember complex figures and 50-digit matrices after only a brief scrutiny of them, but he was able to recall them in detail years later. It was suggested that he was, at least in part, using his synesthetic percepts as an efficient mnemonic device (Luria, 1968/2006).

Other more recent studies have similarly investigated the role of synaesthesia in case studies of mnemonists. Using a similar matrix test to the one used by Luria, Smilek and colleagues (Smilek et al., 2002) tested a grapheme→colour synesthete with an exceptional memory, and it was suggested that her synesthetic colour percepts played an essential role in her memory abilities, by providing additional cues (Smilek et al., 2002). Similar results were obtained by C. B. Mills, Innis, Westendorf, Owsianiecki, and McDonald (2006), when they tested a grapheme→colour synesthete that reported that her synaesthesia helped her in verbal material recall. The results of her testing suggested that her synesthetic percepts were indeed a memory aid for verbal materials, although she did not show a general memory performance benefit.

Importantly, one of the most widely studied cases is that of DT, who is a high-functioning autistic savant with exceptional abilities in numerical memory and mathematical calculations (Azoulai, Hubbard, & Ramachandran, 2005; Baron-Cohen et al., 2007; Bor, Billington, & Baron-Cohen, 2007). DT also has grapheme→colour synaesthesia that he reports using as a strong mnemonic device, and which is likely to contribute to his extraordinary memory abilities (Rothen & Meier, 2010a).

So far, memory studies on synaesthesia have been limited to studies of its two most prevalent forms, grapheme→colour and sequence-space synaesthesia (Gross, Neargarder, Caldwell-Harris, & Cronin-Golomb, 2011; Rothen & Meier, 2009, 2010a; Simner, Mayo, & Spiller, 2009; Terhune, Wudarczyk, Kochuparampil, & Cohen Kadosh, 2013). What these studies reveal is a positive link between synaesthesia and memory. The reason behind this may be twofold: First, the synesthetic experiences themselves may provide a richer world of experience, and an

ability to better structure and organise memory; and second, synaesthesia may be linked to certain structural changes in the brain that are themselves beneficial to memory (Meier & Rothen, 2013). Recent research also demonstrates that synesthetic experiences also enhance memory performance relating to unconscious knowledge (Rothen et al., 2013). Synesthetes themselves overwhelmingly report not only an enhancement of their memory skills (Rich et al., 2005; Yaro & Ward, 2007), but also that synaesthesia facilitates data organisation, and is a source of creative inspiration (Rich et al., 2005).

2.1.6.2. Synaesthesia and specific musical abilities.

Apart from general studies of synaesthesia, creativity, and artistic ability, there have been no studies to date that have specifically looked at the influence of synaesthesia on musical abilities. There are two explanations for this. First, research into the effects of synaesthesia on general abilities have focused on language and learning. This is partly because the most prevalent form, grapheme→colour synaesthesia, lends itself particularly well to this exercise, and also because language is habitually considered of greater importance than other possible areas of research. Second, the study of graphemes is relatively easy in comparison to the study of music in movement, which would engender, for example, colours in movement. It should also be noted that while the semiotics of graphemes and similar symbols are widely known and accepted among the general population, the study of synaesthesia and musical abilities would require a certain level of understanding of musical terminology by the synesthetes themselves.

2.2. Absolute Pitch

2.2.1. Definition of Absolute Pitch

Absolute pitch (AP) is the ability to label or produce a note of a given pitch in the absence of a reference note, with AP possessors providing pitch labels rapidly and effortlessly (Deutsch, 2013). It is otherwise known as perfect pitch, although the label 'perfect' is misleading as AP abilities are present in varying degrees among individuals – a concept that will be further developed within the following sections (Deutsch, 2013; Miyazaki, 1988; Takeuchi & Hulse, 1991; Wilson, Lusher, Wan, Dudgeon, & Reutens, 2009). Absolute pitch is distinguishable from relative pitch (RP), which is a common ability learnt through musical training, in which the pitch of a tone is inferred by comparing it to an external reference tone (Theusch, Basu, & Gitschier, 2009).

The genesis and characteristics of AP are uncertain, and are the subject of considerable research, as will be outlined in this review (Deutsch, 2013). Absolute pitch is a complex trait, and it is hypothesised that both genetic and environmental factors play a role in its genesis (Baharloo, Johnston, Service, Gitschier, & Freimer, 1998; Baharloo, Service, Risch, Gitschier, & Freimer, 2000; Deutsch, 2013; Deutsch, Dooley, Henthorn, & Head, 2009; Deutsch, Henthorn, Marvin, & Xu, 2006). Much of the literature into the role of environmental factors focuses on three factors that are thought to interact in the development of AP: musical training during early childhood, the type of musical training an individual received, and the individual's familiarity with a tone language (Theusch et al., 2009).

Because many historical musical talents, such as Wolfgang Amadeus Mozart, are known to have been AP possessors, it is often regarded as an extremely desirable trait, or even as a 'musical gift' that only occurs in exceptionally gifted individuals (W. D. Ward, 1999).

2.2.1.1. Absolute pitch lies along a continuum.

Absolute pitch appears initially to be a binary, all-or-nothing, trait. Analyses of behavioural performance, however, suggest that the trait exists along a continuum. There is, indeed, growing evidence to support this claim. Absolute pitch possessors and non-possessors were recruited within a population of musically trained subjects in a study by Bermudez and Zatorre (2009), and tested for AP ability. The performance of a substantial number of subjects fell between the AP threshold and chance (1/12, or approximately 8% correct responses). In a separate study by Deutsch, Dooley, Henthorn, and Head (2009), 176 students at the University of Southern California were tested for AP ability. These subjects were tested in class and were not self-selected. The majority of students obtained scores that were consistent with chance, although a substantial proportion of students received scores that were above chance, yet below the cut-off criteria for AP.

2.2.1.2. Classification of absolute pitch possessors.

Absolute pitch possessors have been classified according to the extent of their AP ability. In a large-scale survey of music students, Baharloo, Johnston, Service, Gitscier, and Freimer (1998) developed a simple computer-based acoustical test that allowed them to subdivide AP possessors into four distinct groups, on the basis of their performance. Individuals who were able to label any pitch regardless of timbre

and spectral region were termed AP1 possessors. Individuals who performed at a significantly above-chance level, but who performed at a lower level for pure tone labelling than AP1 possessors, were termed AP2 or AP3 possessors, determined by the distribution of scores. Individuals in the last category were termed AP4 possessors and included individuals whose pitch perception for pure tones was significantly lower than for individuals in the other three categories, although their pitch perception for piano tones remained elevated. It was suggested that the AP4 phenotype could have a differing basis to the other three categories, although this hypothesis remained inconclusive.

In a separate study carried out by Miyazaki (1990), subjects were classified into three subgroups according to their accuracy of response on an AP test. While all subjects were classified as AP possessors, the subgroups were obtained based on the individual's accuracy of response: Group A obtained > 90% accuracy, Group B obtained 70-90% accuracy, while Group C obtained < 70% accuracy. The results of this study demonstrate that the accuracy of pitch identification is significantly different among different pitch classes, with this difference of identification accuracy being the most pronounced in Group C. For subjects in Group C, there was a highly significant effect of note category on their ability to correctly label pitch. White-key notes (without accidentals) were correctly identified at a level comparable to that of Group B, whereas their ability to correctly label black-key notes (notes with accidentals) was markedly decreased. This effect was moderately significant for Group B, but only marginally significant for Group A. This improvement in performance on an AP test for white-key notes was equally observed in a previous study by Miyazaki (1988).

Absolute pitch possessors are known to make octave judgment errors, indicating the predominance of pitch chroma over pitch height in pitch identification. In one study, AP possessors misattributed tones to different registers despite accurately identifying pitch class (Miyazaki, 1989). These finding are however difficult to interpret, for in contrast to the standard terminology used for labelling pitch classes, there is no standard terminology for octave identification (Deutsch, 2013).

2.2.1.3. Absolute pitch, quasi absolute pitch, and relative pitch.

Because AP ability lies along a continuum, the classification of pitch naming ability can also be seen to incorporate relative pitch (RP) and quasi absolute pitch (QAP), alongside traditional AP ability. The traditional view of a distinction between AP and RP can be amended to incorporate QAP as occurring between these two distinct abilities. Relative pitch is an ability all trained musicians learn that allows them to identify or produce musical 'intervals', or relations between pitches, and to label pitches in relation to a given pitch (Levitin & Rogers, 2005). Quasi absolute pitch is a less developed form of AP, where pitch labelling occurs for specific musical notes (Wilson, Lusher, Martin, Rayner, & McLachlan, 2012). Behavioural studies have demonstrated that QAP is reliant on a range of auditory cues, such as timbre, notes with or without accidentals, and pitch register (Athos et al., 2007; Takeuchi & Hulse, 1993). It has been suggested that QAP may be founded on a limited number of AP templates that may be more bound to contextual cues present during perceptual encoding (Wilson et al., 2012).

2.2.2. Prevalence of Absolute Pitch

Absolute pitch is a rare ability, and is estimated to occur in less than one in 10,000, or 0.01% of the general population (Profita & Bidder, 1988; Takeuchi & Hulse, 1993). The prevalence rate of AP is significantly higher in professional musicians. In a survey of musicians, the frequency of self-reported AP was 15% (Baharloo et al., 1998). The rarity of AP is perplexing, and it has been suggested that the lack of AP is analogous to colour anomia, in which patients can discriminate between colours, but are unable to associate them with verbal labels (Deutsch, 2013).

2.2.3. Diagnosis of Absolute Pitch

There is no clear diagnostic response rate for AP possession. In a study of music students, Deutsch and colleagues (2006) used a cut-off score of 85% correct responses as the criterion for AP possession. In a separate study by Wilson and colleagues (2012), high level AP ability corresponded to 80% correct responses or over. Relative pitch possessors were classified as obtaining 20% correct responses or less, while QAP possessors obtained scores falling between these two extremes.

2.2.4. Genesis of Absolute Pitch

There are three general theories relating to the genesis of absolute pitch ability. First, that it is an inherited trait, and therefore of genetic origin. Second, that the ability can be acquired through intensive practice, and this at any life stage. Third, that most people have the potential to acquire AP if exposed to discrete pitches in association with their labels during a critical period early in life.

2.2.4.1. Absolute pitch as an inherited trait.

There are four main arguments concerning AP as an inherited trait. First, the ability

often appears at a very young age, and even before the onset of formal musical training. Second, AP tends to run in families. Third, the neurological underpinnings of AP argue in favour of an innate contribution. Fourth, there are differing prevalence rates of AP in various ethnic groups. These four arguments will be considered separately.

2.2.4.1.1. Absolute pitch ability often appears at a young age.

Absolute pitch possessors often remark that they have had AP for as long as they can remember (Carpenter, 1951). Descriptions of family members who discover the AP ability of the young child, before the beginning of musical training, are also frequent (Corliss, 1973). In this instance, formal musical training may be instigated by the family in response to the perceived ability of the child.

2.2.4.1.2. Absolute pitch tends to run in families.

The second argument for the genetic view of AP is that it tends to run in families (Deutsch, 2013). In a survey of 600 musicians, self-reported AP possessors were four times more likely to report a family member with AP than their non-possessor counterparts (Baharloo et al., 1998). Other studies support these findings (Baharloo et al., 2000; Gregersen, Kowalsky, Kohn, & Marvin, 1999, 2001; Profita & Bidder, 1988). The demonstration of a genetic contribution to AP will ultimately require the discovery of a gene or genes that contribute to this trait. Preliminary evidence of this has been provided in a study by Theusch, Basu, and Gitscher (2009), who demonstrated a genome-wide linkage on chromosome 8 for AP in families of European descent. Further evidence that the development of AP is influenced by the genetic makeup of the individual has been provided by familial aggregation studies

(Baharloo et al., 2000), and twin observations (Gregersen, 1998; Theusch & Gitschier, 2011). In one recent study undertaken by Theusch and Gitschier (2011) the AP concordance rate of monozygotic twin pairs (78.6%) was significantly different from that of dizygotic twin pairs (45.2%), supporting the role of genetics in the development of AP.

There is, however, a need for caution when examining the results of familial aggregation studies for two reasons. First, infants born into families with at least one AP possessor may be subject to hearing notes and their labels early in life, and would therefore have the opportunity to acquire these pitch-label associations at a very young age (Deutsch, 2013). Furthermore, as will be discussed in the next section on 'absolute pitch and early life exposure', the probability of acquiring AP is dependent on musical training at a young age, and it has been suggested that early musical training is itself familial (Baharloo et al., 2000).

2.2.4.1.3. The neurological underpinnings of absolute pitch.

The neurological foundations of AP have been explored in numerous recent studies, and evidence suggests that AP possessors have a uniquely structured brain (Deutsch, 2013). Using diffusion tensor imaging and tractography, Loui, Li, Hohmann, & Schlaug (2011) observed local hyperconnectivity in AP processing brain regions, extending previous reports of a network of cortical areas that are uniquely structured and recruited among AP musicians (Bermudez & Zatorre, 2009; Keenan, Thangaraj, Halpern, & Schlaug, 2001; Oechslin, Meyer, & Jancke, 2010; Ohnishi et al., 2001; Schlaug, Jancke, Huang, & Steinmetz, 1995; Wilson et al., 2009; Zatorre, Perry, Beckett, Westbury, & Evans, 1998). It has been suggested by Loui et al. (2011) that

these findings may provide a model to explain the higher incidence of AP in synaesthesia, as well as in developmental disorders such as autism spectrum disorders (ASD) and Williams syndrome, and may provide a model for understanding the heightened connectivity that is thought to underlie savant skills and cases of exceptional creativity. It has been noted, however, that the role of neuroplasticity in the development of the uniquely structured brain circuitry of AP possessors remains to be resolved (Deutsch, 2013).

2.2.4.1.4. The prevalence of absolute pitch in different ethnic groups.

The varying prevalence of AP in diverse ethnic groups contributes to the argument in favour of a genetic influence on AP. Several studies have demonstrated that there is a significantly higher prevalence of AP in people of East Asian descent, although speculation continues as to the reason for this disparity. This population difference has been attributed to three factors: genetic contributions, type of musical training, and early exposure to a tone language. The genetic contribution to this population difference has been suggested by Athos and colleagues (2007), Baharloo and colleagues (1998), and Gregersen and colleagues (1999). In a later study, Gregersen and colleagues (2001) concluded however that the type of musical training young children were exposed to was likely to be causal. Interestingly, Deutsch and colleagues (Deutsch, Henthorn, & Dolson, 2004a, 2004b; Deutsch et al., 2006) suggest early exposure to a tone language may be a determining factor for this population difference.

Several large-scale direct-test studies have found a correlation between the prevalence of AP and tone language fluency among music students (Deutsch, Dooley, et al.,

2009; Deutsch et al., 2006; Lee & Lee, 2010; Peng, Deutsch, Henthorn, Su, & Wang, 2013; Wilson et al., 2012). In tone languages, the meanings of words change depending on the tones in which they are enunciated, whereas the pronunciation of the word remains the same. When a tone language speaker attributes the meaning of a word to the tone it is spoken in, the speaker is associating a verbal label to a particular pitch. An analogy can be made between this mechanism and that employed by an AP possessor, who associates a verbal pitch label to a particular pitch (Deutsch, 2013).

The hypothesis that AP is more prevalent among speakers of tone languages was examined in three studies undertaken by Deutsch (Deutsch, Dooley, et al., 2009; Deutsch et al., 2006; Deutsch, Le, Shen, & Li, 2011). In the first of these studies (Deutsch et al., 2006) a large-scale direct-test study examined two groups of students from two music conservatoriums. The first group comprised students at the Central Conservatory of Music in Beijing, China, while the second group comprised students at the Eastman School of Music, USA. The students in the first group were Mandarin speakers (a tone language), whereas the students in the second group were non-tone language speakers. While the results of this study demonstrate an effect of age of onset of musical training on AP scores for both groups, the tone language speakers showed significantly higher scores than the non-tone language speakers for all levels of age of onset of musical training. Although this study seems to demonstrate the effects of speaking a tone language on AP acquisition, there was another possible explanation for this effect. As all of the participants in the first group were East Asian, while all of the participants in the second group were Caucasian, the findings could alternatively be interpreted as indicating a genetic basis for the capacity to acquire AP (Deutsch, Le, et al., 2009).

Due to the interpretative ambiguity of the results found in the Deutsch and colleagues (2006) study, a further study was carried out by Deutsch, Dooley, and colleagues (2009) to re-examine in more detail the correlation between AP ability and language, and additionally consider the country of music education of participants as an alternative interpretation. Participants were recruited from the USC Thornton School of Music, USA, and were assigned to one of four groups: the first group was of non-tone language speakers, while the remaining participants were assigned to one of three groups depending on their level of tone language fluency. This study uncovered a strong relationship between the prevalence of absolute pitch and tone language fluency, while the country of music education had no significant effect on AP acquisition. In a further large-scale study, Deutsch, Li, and Shen (2013) tested students at the Shanghai Conservatory of Music, China, for AP. The effect of age of onset of musical training was again evaluated, as was gender. While the effect of gender was nonsignificant, the effect of age of onset of musical training was found to be highly significant. These findings are in accordance with the conjecture that AP acquisition for tone language speakers involves the same neural circuitry as is involved in the acquisition of the tones of a tone language (Deutsch, 2013).

2.2.4.2. Absolute pitch acquired through intensive practice.

The acquisition of AP in adulthood through intensive practice has been attempted in several studies. Two general methods have been used to teach absolute pitch identification. In the first method, subjects were asked to identify heard notes, and subsequently informed of the correct pitch. This method was used in studies by Gough (1922), Meyer (1899), Mull (1925), and Wedell (1934). After varying lengths

of practice with this task, pitch identification without feedback improved in all studies, but this improvement was not at a level equivalent to AP possessors.

In the second method, subjects were first taught a single pitch which they heard repeatedly and learn to discriminate among all other pitches. During the early stages of discrimination training, this pitch occurred on half the trials. The frequency of the standard pitch decreased as training proceeded, until all pitches had an equal probability of being presented. This method was used in studies by Brady (1970), and Cuddy (1968). An unusually positive finding was described by Brady (1970), who claimed to have taught himself AP. After 60 hours of training using the single-tone method, Brady achieved a success rate of 96.5% (allowing for semitone errors). There were, however, limits to his ability when compared to that of AP possessors. He was not only unable to identify the simultaneous audition of multiple tones, but he was also unable to identify pitches in non-melodic contexts. While the improvement demonstrated by this single case-study is notable, these findings do not convincingly demonstrate that the acquisition of AP in adulthood is possible (Deutsch, 2013; Takeuchi & Hulse, 1993). The demonstrated difficulty of acquiring AP in adulthood lies in contrast to the apparently effortless and unconscious acquisition of AP in early childhood (Deutsch, 2013).

2.2.4.3. Absolute pitch and early life exposure.

A significant relationship between AP possession and early age of onset of musical training has been demonstrated by numerous studies. Small-scale studies (Dooley & Deutsch, 2010, 2011; Levitin & Rogers, 2005; Profita & Bidder, 1988) and surveys (Baharloo et al., 1998; Gregersen et al., 1999) have observed a strong correlation

between early musical training and AP ability. In a survey of over 2,000 music students, self-reported AP possessors commenced musical training at an average age of 5.4 years (Gregersen et al., 1999). In a separate survey of 600 musicians, 40% of participants who had begun musical training before the age of 4 had self-reported AP. In contrast, 27% of participants who had begun training between the ages of 4-6 had self-reported AP, 8% between the ages of 6-9, and 4% between the ages of 9-12 (Baharloo et al., 1998). This correlation has been confirmed by large-scale studies, as mentioned in section 2.2.4.1.4. ('The prevalence of absolute pitch in different ethnic groups'), where this correlation was determined to be highly significant (Deutsch, Dooley, et al., 2009; Deutsch et al., 2006; Deutsch et al., 2011; Lee & Lee, 2010).

2.2.4.3.1. Type of musical training.

The type of early musical training that a child is exposed to plays a critical role in AP acquisition. There are two methods of musical training: the 'fixed-do', and 'moveable-do' methods. In the fixed-do system, solfège symbols define actual pitches, and as such 'do, re, me' is equivalent to 'C, D, E'. In the movable-do system, solfège symbols are used to define the roles of pitches relative to the tonic, while the actual pitches are defined by letter names; hence 'do' refers to the tonic, but not necessarily to the pitch 'C'. In a large-scale survey of American music students, Gregersen and colleagues (2001) attempted to establish the nature of the musical training these students received before the age of 7. It was observed that AP possessors were more likely to have had fixed-do rather than moveable-do training, although it was acknowledged that other factors were also causal in these results.

A study undertaken by Peng and colleagues (2013) explored the issue of the type of

early musical training that a child obtains, with two extensions. First, the study extended its population sample to include students from regular universities, and not just music conservatories, to obtain a sample more representative of the general population. Second, to investigate the effect of different methods of musical training, participants were given the option of responding on the AP test using either fixed-do or moveable-do terminology, so indicating the type of training they had received. The performance level on the AP test was significantly higher among those who were native tone language speakers compared with those who were non-tone language speakers, consistent with findings from previous studies. The probability of acquiring AP ability was positively related to the age of onset of musical training, again consistent with previous research. Interestingly, the performance of subjects who had received moveable-do training was higher than that of subjects who had received fixed-do training, and this effect was positively correlated to age of onset of musical training. While this result was nonsignificant, and likely due to the small sample size of the fixed-do group (n = 7), these findings demonstrate that fixed-do training cannot account for the high level of performance of the Chinese subjects in this study.

The assumption that the type of early musical training a child receives is critical in AP acquisition is supported by the notion that children who are first taught on transposing instruments, such as the trumpet or clarinet, are at a clear disadvantage (Deutsch, 2013), although this hypothesis remains to be empirically tested. It has been demonstrated, however, that subjects trained on Western-style musical instruments substantially outperformed subjects trained with folk or vocal music (Peng et al., 2013).

2.2.5. Implicit Absolute Pitch

The majority of the general population possess an implicit form of AP, even though they are unable to supply pitch labels for the notes they are judging. This has been confirmed through studies using both pitch production and pitch identification tasks.

2.2.5.1. Pitch production.

In a landmark study, Levitin (1994) suggested the existence of absolute pitch memory for music in the general population, beyond the rare occurrence of genuine AP ability. In this study, 46 subjects were asked to sing two different pop songs of their choice, and their productions were compared with the actual pitches used in recordings of those songs. In this sample, 44% percent of participants sang the correct pitch on at least one of two trials, and 12% were correct on both trials. In a large-scale study (n = 277) by Frieler and colleagues (2013) the Levitin study was replicated, with participants asked to sing two different pop songs of their choice. These vocal renditions were then compared to the original pop songs. The exact pitch of at least one of the two songs was sung by 25% of the participants, while the exact pitch of both songs was sung by 4% of the participants. These results generally confirm the findings of Levitin, although the results of both tests illustrate the variability of empirical findings derived from small and large sample sizes.

In a separate study by Bergeson and Trehub (2002), mothers were asked to sing the same song to their infants over two sessions separated by at least a week. For each participant, the pitch range of each individual song over the two sessions deviated on average by less than a semitone. In these three studies, participants without AP

successfully retrieved the correct pitch of familiar songs from memory. This phenomenon has been termed ‘latent AP’ by Levitin (1994), ‘residual AP’ by Takeuchi and Hulse (1993), and more recently ‘implicit AP’ by Deutsch (2013). The nomination of this phenomenon as implicit AP is concurrent with a trend in the literature exploring other absolute features of music (Frieler et al., 2013) including tempo (Levitin & Cook, 1996) and timbre (Schellenberg, Iverson, & McKinnon, 1999).

2.2.5.2. Pitch identification.

Different pitch identification tasks have confirmed the presence of AP in different subgroups of the general population, from infants to musically literate subjects. A study by Saffran and Griepentrog (2001) demonstrated that implicit AP occurs in the early stages of life, and even before the acquisition of speech. When performing a statistical learning task, 8 to 9-month old infants were shown to be more likely to track patterns of absolute pitches rather than patterns of relative pitches.

To evaluate the prevalence of implicit AP in the general population, unselected college students were presented with the theme songs of then-current television shows (Schellenberg & Trehub, 2003). It was found that the participants were able to identify which songs had been transposed by up to two semitones at a level above chance. A further experiment was undertaken with unselected members of the general population, using the two North American telephone dial tones (Smith & Schmuckler, 2008). These tones had been constant for decades and would therefore have been heard many times by members of the general public. Participants were played various pitch-shifted versions of the dial tones, and were asked to classify each example as normal, or higher or lower than normal. The results support the idea that some form of

AP memory is present in the general population, although it was conceded that participants in this study were also influenced by contextual and relative pitch information.

In a study of the implicit AP ability of musicians, participants were presented with short excerpts of preludes from the *Well-Tempered Clavier,* Vol. 1, by J. S. Bach, either in an original, or transposed, version (Terhardt & Seewann, 1983). Participants were asked to determine if the excerpt they were hearing was in its original key, or not. In the main experiment 45% of participants were able to judge the original key from one-semitone transpositions, while 78% of participants were able to judge transpositions of up to four semitones. A similar study was undertaken with 52 non-absolute pitch student musicians (Vitouch & Gaugusch, 2000). The participants were presented on several subsequent days with the first *Prelude in C major* by J. S. Bach, either in the original key, or transposed by one semitone. Participants significantly outperformed chance in musical key recognition, indicating that implicit AP may be widespread among individuals with musical experience, and that the continuum view of AP is more justifiable than the idea of a discrete distinction between 'possessors' and 'non-possessors' of AP ability.

2.2.6. Absolute Pitch and Musical Ability

Absolute pitch ability is often synonymously linked to enhanced low-level auditory abilities. Experimental studies using frequency discrimination tasks have not confirmed this view, demonstrating no difference in performance on these tasks between AP possessors and non-possessors (Fujisaki & Kashino, 2002; Siegel, 1972). It has been demonstrated however that the performance of AP possessors on tasks

related to high-level pitch processing differs from the performance of non-possessors. There are four areas where the performance of these two groups has been shown to differ: pitch memory tasks, musical dictation, interval identification, and relative pitch processing.

2.2.6.1. Absolute pitch and pitch memory.

Possessors of AP perform better on certain pitch memory tasks (Bachem, 1954; Rakowski & Rogowski, 2007; Siegel, 1974). The performance of AP possessors on a pitch memory task was compared to that of musically trained non-possessors in an early study by Bachem (1954), where participants were asked to indicate whether a standard tone and a comparison tone were the same or different. The elapsed time between the presentations of both tones differed from one minute to one week. The two groups showed no significant difference in the decay rate of pitch memory for the one-minute elapsed time interval, although only AP possessors performed accurately after a one-week interval. For time intervals that fell between these two extremes, the performance of non-possessors continued to deteriorate, while the performance of AP possessors remained stable.

In a separate experiment, two test tones were presented to participants, with intervening tones played between both test tones (Siegel, 1974). Participants were asked to judge whether the test tones were the same pitch or different pitches. Over a 5 second retention interval, and with a 1/10 semitone difference in pitch between both test tones, the performance of both groups declined at a comparably similar rate. Over a 15 second retention interval, and with a 1 semitone difference in pitch, however, there was a significant difference between the two groups, with the performance of

non-performers deteriorating sharply, while the performance of AP possessors remained stable.

In a small-scale study of 2 AP possessors and a control non-possessor, the participants were presented with a standard tone, followed by a variable tone that they were asked to tune to match the pitch of the initially presented standard tone (Rakowski & Rogowski, 2007). When a silent interval of up to one minute was interposed between the standard and variable tones, both AP possessors and non-possessor performed at a comparable level. When, however, a silent interval of greater than one minute was interposed between both tones, the performance of the non-possessor declined accordingly, whereas the performance of the AP possessors remained stable.

The results of these three studies suggest that the performance stability of AP possessors is due to their assignment of verbal labels to pitch classes, and as such to their adoption of a verbal encoding strategy. This would enable them to benefit from long-term memory during longer retention periods.

2.2.6.2. Absolute pitch and musical dictation.

Absolute pitch has been associated with superior musical dictation abilities. To examine this hypothesis Dooley and Deutsch (2010) employed a musical dictation task modelled after a first-year University placement examination. Based on their performance on an AP test, thirty musically trained subjects were divided into three groups: AP possessors, borderline possessors, and non-possessors (Dooley & Deutsch, 2010). Participants transcribed three passages during a music dictation task, with the starting note given as a reference for each passage. A positive relationship

was shown between performance on the AP test and the musical dictation tasks, with the performance level being significantly higher for AP possessors than for borderline possessors, and significantly higher for borderline possessors than for non-possessors. Neither age of onset of musical training nor years of musical training had a significant effect on the dictation scores.

2.2.6.3. Absolute pitch and interval identification.

The relationship between AP and interval identification was examined in a further study by Dooley and Deutsch (2011). Musically trained subjects, both AP possessors and non-possessors, were given three interval-naming tasks to complete. The tasks only required relative pitch, and participants were asked to identify the intervals using interval names, such as major or minor third. The first two tasks consisted of intervals formed by sine waves and piano tones. The third task consisted of intervals formed by piano tones, with each interval preceded by an authentic 7th cadence. For all three tasks, including during the tonal context of the third task, there was a strong and positive correlation between AP possession and interval identification performance. What these finding demonstrate is that AP possession is positively associated with musical tasks requiring only relative pitch.

2.2.6.4. Absolute pitch and relative pitch processing.

While the two Dooley and Deutsch (2010, 2011) studies mentioned above demonstrate the positive association of AP possession and relative pitch processing in musical dictation and interval identification, there is evidence that AP possessors may be at a disadvantage in certain distinct situations where relative pitch processing is required. One example is when music is transposed, or when AP possessors hear

music played in a different key to the written score they are reading (Deutsch, 2013). While these situations can leave AP possessors with a feeling of discomfort, non-possessors do not share this reaction.

In a study by Mito (2003), both AP possessors (n = 10) and non-possessors (n = 10) were recruited from a population of university music students. All 20 students were pianists, and the task consisted of sight-reading excerpts of music by Bach or Chopin on either a normal or transposed keyboard. The use of a transposed keyboard was intentionally designed to make the perception of AP more difficult, and to subsequently examine the RP ability of AP possessors. Errors produced by both groups during sight-reading tasks on both the normal and transposed keyboards were analysed, and the total number of errors made by each individual participant in each condition was tabulated. No differences were reported between the number of total errors in the transposed and normal conditions for non-possessors. In contrast, AP possessors made a significantly higher number of errors in the transposed condition than in the normal condition. Based on these results, it was suggested by Mito that AP possessors have weak or underdeveloped relative pitch perception, and that AP ability is not always advantageous to musical activities.

2.3. Synaesthesia and Absolute Pitch Research

Synaesthesia and absolute pitch are two uncommon cognitive traits that reflect increased neuronal connectivity and have been anecdotally reported to occur together in individuals (Bernard, 1986; Gregersen et al., 2013; Hänggi et al., 2008). It has been suggested that AP can be defined as a reversal of the prototypical manifestation of synaesthesia, which involves experiencing a sensory stimulation, such as colour,

when exposed to a perceptual inducer, such as a grapheme (Mottron et al., 2013). What both abilities require, however, are involuntary and stable mappings between perceptual and verbal representations (Mottron et al., 2013).

While the co-occurrence of synaesthesia and AP in professional musicians has been noted in case studies (Bernard, 1986), research into the relationship that exists between these two conditions is recent, with only five known studies having addressed this subject. These five studies will be discussed in chronological order, ending with the latest known study.

2.3.1. Study 1

In a study of 10 sound→colour synesthetes and 10 controls, aimed at investigating how different aspects of an auditory stimulus are mapped on to the visual domain in both synesthetes and controls, J. Ward and colleagues (2006) discussed intriguing parallels that exist between sound→colour synaesthesia and AP. As has been hypothesized with synaesthesia, it has been suggested that AP could be an outcome of neural pruning (Keenan et al., 2001), and that all infants may be born with the ability (W. D. Ward, 1999). J. Ward and colleagues (2006) questioned whether sound→colour synesthetes could use their colour percepts in order to deduce the identity of a note, and thus acquire a cognitive form of AP ability, although none of the study sample reported this ability. This led J. Ward and colleagues to conclude that four separate conditions would be necessary for this to occur. First, that notes a semitone apart must have perceivable differences in colour. Second, that the context in which the note is played (such as the instrument playing the note) would not modify the colour percept. Third, that the perceptual differences can be committed to

long-term memory; and finally, that these stored perceptual differences can acquire linguistic labels. While these are all testable questions, they have not as yet been addressed.

2.3.2. Study 2

It has been demonstrated in a neuroanatomical case study of a professional musician with AP and multiple forms of synaesthesia, that the auditory cortical regions of the synesthete musician brain differ significantly from those typically found in non-synesthete musicians (Hänggi et al., 2008). The synesthete documented in this study, ES, is a professional musician with AP, musical interval→taste synaesthesia, and tone→colour synaesthesia. In 2005, the case of ES's interval→taste synaesthesia became the first documented case of this form of synaesthesia (Beeli, Esslen, & Jäncke, 2005). During the 2008 study by Hänggi and colleagues, her brain was compared with the brains of 20 normal control females and 17 female musician controls – 10 of whom were AP possessors. As hypothesised, large structural differences were revealed between the brain of ES and those of the controls, in the auditory cortices, and in the gustatory and visual areas. These results provide evidence for a neuroanatomical basis of synesthetic experiences for the two types of synaesthesia experienced by ES. Surprisingly, the results of this study showed a reduction in grey matter volume in auditory areas of ES's brain, which is unexpected in musicians with AP (Luders, Gaser, Jäncke, & Schlaug, 2004). It was concluded that, as by her own admission, she uses her tone→colour synaesthesia to identify the pitch of a tone, this cognitive problem-solving mechanism rendered a reorganisation of her auditory areas unnecessary (Hänggi et al., 2008).

2.3.3. Study 3

The degree to which neural substrates recruited for music listening may be shared between synesthetes and AP possessors was investigated in a neuroimaging study by Loui, Zamm, and Schlaug (2012). In a sparse-sampled fMRI study, tone→colour synesthetes, AP possessors, and matched controls were asked to rate the perceived levels of arousal of selected musical excerpts. The results of this study support both shared and distinct neural enhancements in AP and tone→colour synaesthesia. The common enhancements revealed in early cortical mechanisms of perceptual analysis, followed by relative specialization in later association and categorization processes, support the unique behaviors of synesthetes and AP possessors during music listening.

2.3.4. Study 4

Superior perception, peaks of ability, and savant skills are often observed in the autistic phenotype, accompanied by a significantly higher prevalence of AP and synaesthesia. A study undertaken by Mottron and colleagues (2013) proposes that savant abilities such as AP and synaesthesia involve similar neurocognitive components, share the same structural and developmental progression, and represent related ways by which the perceptual brain deals with objective structures under different conditions. The prevalence of AP in autism spectrum disorders (ASD) has been estimated at between 5-11% (DePape, Hall, Tillmann, & Trainor, 2012; Rimland & Fein, 1988), compared to 0.01% in typical populations (Takeuchi & Hulse, 1993), and is consistently observed among savant autistic musicians (Miller, 1999; Sloboda, Hermelin, & O'Connor, 1985; Young & Nettelbeck, 1995). Mottron and colleagues (2013) also note that autistic features are also observed in AP possessors, indicating a non-random link between the two conditions. The prevalence of synaesthesia in adults

with autism was reported to be 18.9% by Baron-Cohen and colleagues (2013), in comparison to the highest estimated prevalence rate of 4.4% in the general population (Simner, Mulvenna, et al., 2006). While the link between savant syndrome, AP and synaesthesia has been previously debated, and the co-occurrence of these conditions has been proposed to increase the likelihood of savant syndrome, the reason for this has not as yet been explained (Bor et al., 2007). In conclusion, Mottron and colleagues indicate that the atypical neural connectivity characteristic of ASD is consistent with the resulting high prevalence of savant abilities, absolute pitch, and synaesthesia in ASD.

2.3.5. Study 5

There is a significantly higher prevalence of synaesthesia in populations of AP possessors. In a survey by Gregersen and colleagues (2013), the occurrence of synaesthesia in a population of 768 subjects with documented AP was evaluated. Of the 768 AP possessors, 151 of them (20.1%) reported being synesthetes, with colour being the most common concurrent. This is significantly higher than the highest estimated prevalence rate of 4.4% in the general population (Simner, Mulvenna, et al., 2006). A combined linkage analysis of 53 multiplex families with AP and 36 multiplex families with synaesthesia was undertaken, with the results demonstrating a close phenotypic and genetic relationship between AP and synaesthesia. While this study was unable to definitively establish the identity of a causative gene or genes involved in the neurodevelopment of AP and synaesthesia, it did provide a formal analysis of the anecdotally reported proposition that AP and synesthetic experiences may occur together. Furthermore, Gregerson and colleagues noted the higher occurrence rate of AP and synaesthesia in subjects with ASD and proposed that

defining the genetic basis of AP and synaesthesia may provide insights into the genetics and neurobiology of ASD.

2.4. Summary

This literature review has established the validity of considering synaesthesia and AP as two distinct, authentic, and diagnosable neurological conditions. Moreover, the review confirms that empirical testing can lead to insights into the effects of these two conditions on musical development and has explored some of the causal factors that may point to common neurological underpinnings between these two conditions. Research cited in this review demonstrates that considering these conditions as random occurrences and independent mechanisms is not tenable, but that on the contrary they reflect the action of the same neurocognitive mechanism, applied to different domains. This is consistent with the observation that synaesthesia and AP are found to frequently co-occur not only among people on the autism spectrum, but also among the general population.

This review has uncovered two key questions that remain largely unanswered in the existing literature. First, there are no studies to date that have investigated the influence of synaesthesia on musical development, and while studies on the influence of AP on specific musical abilities have been undertaken, no studies have been identified that investigate the effects of AP on a possessor's motivation to continue musical studies, their affective response to their condition, or general cognitive benefits. Second, while the co-occurrence of synaesthesia and AP has been frequently noted, this relationship has yet to be explored from a musical perspective. For this reason, these questions are addressed in this study.

Chapter 3

Design and Methodology

This study explored the impact of synaesthesia and absolute pitch (AP) on musical development. It involved a population of advanced level tertiary musicians at the Melbourne Conservatorium of Music (MCM), the University of Melbourne (Australia). The first priority of this study was to seek out auto-diagnosed cases of both synaesthesia and AP within the population of music student and academic staff. After preliminary assessment, the private perceptual experiences of these auto-diagnosed cases were then subjected to verification and quantification through the use of test batteries. The major purpose of this study was to address the two research aims identified in Chapter 1, whose objectives are to identify the degree to which synaesthesia and/or absolute pitch (AP) possession may facilitate or impair the cognitive, affective, and behavioural outcomes of musical development, and to investigate the potential interaction between both conditions.

The data collected during the study consisted of information obtained from an online survey, a semi-structured interview, and synaesthesia and AP test batteries. These were administered to participants over three separate sessions.

This chapter describes the design and implementation of the study according to three sections:

1. The first section outlines the choice of method used for this study, including its description, its challenges and benefits, the determination of its key principles, and the final choice of study design.
2. The second section provides a justification for restricting the study to an investigation of Conservatorium students and staff with auto-diagnosed cases of synaesthesia and/or AP, and describes the attainment of ethics clearance. This section also describes the sample used in the study, and the means by which this sample was selected.
3. The third section details the measures and procedure employed in this study, including the development of a survey, interview, and absolute pitch test battery used to assess participant ability in pitch naming tasks. This section also covers the administration of the measures, the equipment used, and the data analysis techniques employed in evaluating the results obtained.

3.1. Choice of Method

Research methods enable a researcher to collect, analyse, interpret, and report data in logical and methodical ways. The choice of method was thus made based on identifying the design that would optimally address the research questions and the exploratory nature of this study.

In consideration of the rationale, procedures, strength, challenges, and variants of a number of methodological designs, a mixed-method approach was chosen. This approach provides an effective combination of both structure and flexibility, critical to this exploratory study, where one data source alone would be insufficient. This

synergistic approach enables theoretical considerations to be advanced through the use of both quantitative and qualitative research methods.

3.1.1. A Description of Mixed Methods Research

Mixed methods research involves the collection of both qualitative and quantitative data (Creswell, 2014). Both of these forms of data are integrated and merged in the design analysis. The collected data and subsequent analysis are rigorously conducted and incorporated in a distinct mixed methods design that included concurrent and/or sequential timing of the data collection, as well as an equal or unequal emphasis for each database. The decisions taken concerning this specific study and the rationale underscoring these choices are outlined in the following sections.

3.1.2. Challenges and Benefits of a Mixed Methods Approach

The decision to apply a mixed methods approach exposed several challenges, including the need to collect extensive amounts of data and time-intensive data analysis (particularly in the analysis of the interview transcripts).

Combining methods is challenging, however the considerable benefits in terms of research outcomes made the decision an evident one. The rationale underpinning this methodological decision is manifold. As per considerations outlined by Greene, Caracelli, and Graham (1989), as well as by Bryman (2006), several important reasons emerged.

1. To enhance the validity of the research outcomes, by combining findings to mutually corroborate results and seek correspondence from different methods.

2. To elaborate, illustrate, and clarify the results of one method with the results of the second. This includes were unexpected results were obtained. In particular, the quantitative data collected will be used to illustrate qualitative findings.
3. To facilitate the sampling of these unique population groups.
4. To enhance the credibility and integrity of the findings.
5. To provide contextual understanding through qualitative findings, coupled with broad relationships among variables uncovered through quantitative findings. In this way, the breadth and range of inquiry will be expanded.

These reasons form the foundation for the general framework of how the research design was matched to advantageously support the research questions and study purpose.

3.1.3. Determining Key Design Principles

In choosing the appropriate design to be used for this study, the level of interaction, priority, timing, and procedures for mixing qualitative and quantitative strands needed to be determined (Creswell & Plano-Clark, 2011). These four key decisions are outlined below.

3.1.3.1. Determining the level of interaction.

For this study, an online survey, semi-structured interview, and synaesthesia and AP test batteries, were used as data collecting tools. The development of these tools will be described in Section 3.3. ('Measures and procedure') below. The level of interaction between qualitative and quantitative strands is the extent to which the two

strands are kept independent or interact. In this study there is a direct interaction between the two strands before the final interpretation. This interaction is particularly apparent in the development and implementation of an online survey, which directly precedes and informs a semi-structured interview. The responses provided on the survey informed the questions asked during the interview, while the interview was also used to verify or clarify responses given on the survey. Conversely, the synaesthesia and AP tests were run independently to the survey and interview, and data collected through these tests were not used in an interactive manner before the final analysis phase.

3.1.3.2. Determining priority.

This study is largely exploratory, and focused on revealing the lived-world experiences of musicians with synaesthesia and/or AP. To optimally answer the research questions, this study utilises a qualitative priority, where a greater emphasis is placed on the qualitative method. In particular, it was explicitly determined that the greatest weight would be afforded to qualitative data collected during the interview phase. In addressing the research questions, the quantitative methods employed, including the synaesthesia and AP tests, will thus be used in a secondary role.

3.1.3.3. Determining timing.

The implementation of the different strands of data collection and analysis occurred using multiphase combination timing, where both concurrent and sequential timing was employed. As such, data was collected from the online survey prior to the interview phase, and this data went through a preliminary analysis with the results of

this analysis used to inform the structure of the interview template (sequential timing). Based on the interview discussion, as well as the potential synaesthesia diagnosis made during the interview, the choice of subsequent synaesthesia and/or AP test was made and implemented (see Figure 3.1). Data from the survey, interview, and synaesthesia and AP tests, underwent a final analysis during a single phase (concurrent timing).

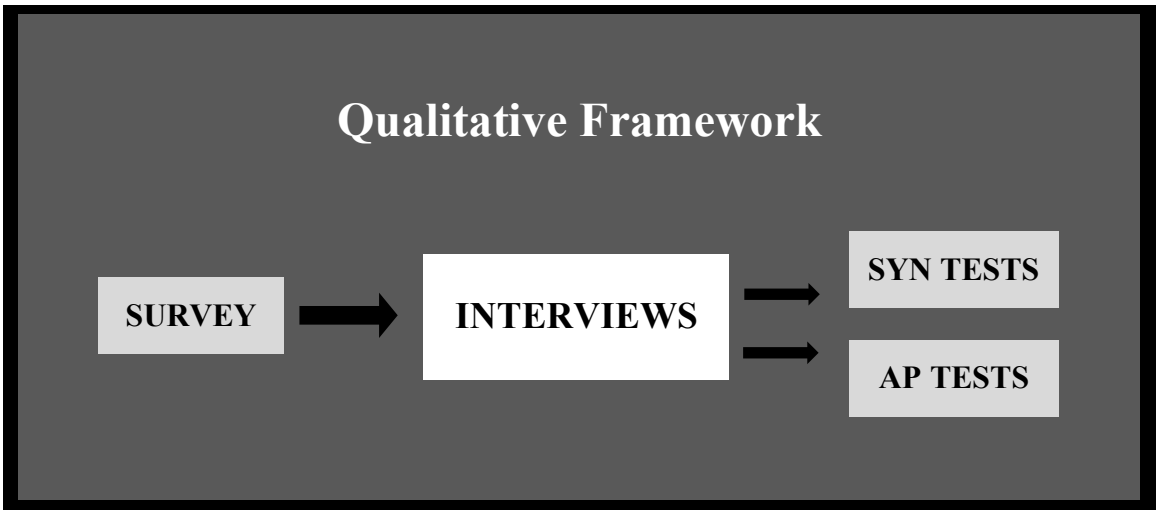

Figure 3.1. The implementation of the various data collecting stages. These three stages were sequential, with each stage informing the next. While this data collecting strategy was sequential, it fits within a broader multiphase combination timing strategy, where data collected from all sources was merged, and underwent a final analysis concurrently.

3.1.3.4. Determining procedures.

The final determination to make in choosing the appropriate study design involved deciding the process to interrelating qualitative and quantitative approaches within this mixed methods design. Four points of integration were explicitly determined, beginning at the very earliest level of the study's design.

As previously stated, greater emphasis was afforded to the qualitative strand of this study, and therefore an embedded mixing strategy was chosen, where supplementary quantitative strands were embedded within the larger qualitative, or narrative, design. Second, mixing occurred during the data collection phase (see Section 3.1.3.3.: 'Determining timing' above). As such, the results of one strand (online survey), inform the shaping of the subsequent collection of qualitative data (interview). Third, mixing occurred during data analysis, where both strands of data were explicitly merged through a combined analysis. This interactive strategy included the transformation of qualitative data collected during the interview process into quantitative data, before merging these sources and performing additional analyses of the transformed data. Finally, mixing occurred during the final stage of the study design, where conclusions were drawn after reflection on, and interpretation of, a synthesis of results from both qualitative and quantitative strands. These conclusions are presented in the discussion chapter (see Chapter 8).

3.1.4. Choice of Type of Mixed Methods Design

An overview of the combination of these four key decisions produces a clearly defined direction for this research. Qualitative and quantitative strands interact within the study design, with a direct interaction between the survey and interview components, while synaesthesia and AP tests were run independently. This study uses a qualitative priority, with multiphase combination timing employed for data collection and analysis. Through an embedded mixing strategy, supplementary quantitative strands were embedded within the larger qualitative design, with mixing occurring during the data collection, data analysis, and final study design stages of this study.

After reflecting on these decisions and the rationale they support, a clear choice of appropriate study design emerged. These methodological choices are best reflected in a mixed methods embedded design, and this is the design chosen.

3.1.4.1. The embedded design.

The basic mixed methods embedded design allows for both qualitative and quantitative data collection and analysis within a more traditional study focused on one of these methods (Creswell & Plano-Clark, 2011; Greene, 2007). For the purposes of this study, the qualitative method is focused on within this mixed methods embedded design. The addition of the supplementary quantitative strand enhances the overall design, by providing a more complete understanding of the two conditions being studied (see Figure 3.2).

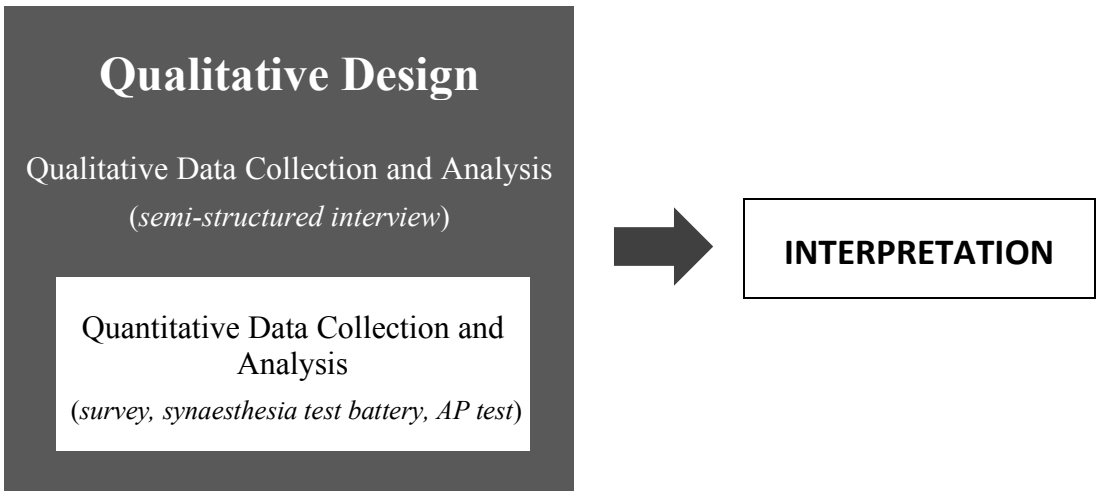

Figure 3.2. Depiction of the qualitative focus of this mixed methods embedded design. It includes a description of data collection tools used in this study and their placement within the design.

The embedded quantitative strand is depicted in Figure 3.2 as providing a secondary, supportive role within the study design. This said, the interaction between these two

strands is an important aspect of this study, as evidenced by their interaction at every level of procedural design (see Section 3.1.3.4.: 'Determining procedures' above). Furthermore, the purpose of collecting data through each strand differs. The primary purpose of this research is to examine the impact of synaesthesia and/or AP on musical development. As this is an exploratory study, a qualitative, discourse driven study was deemed optimal to address this research question. The priority was given to data collected through semi-structured world-view interviews, while synaesthesia and AP tests were included to support this data by verifying and quantifying these conditions. The initial online survey was included to both inform the subsequent interview framework, as well as provide demographic information for individual participants. To supplement this quantitative data, qualitative data collected during the interviews was transformed into quantitative data, and subsequently merged and analysed collectively. This interactive strategy enables a symbiosis of data collected through both strands, broadening our insight into these conditions and their impact on the musical development of individual participants.

3.2. Description of Sample

Once the choice of method had been adopted, planning attention turned to the study sample. Ethical considerations had to be made, as well as factors such as sample size and selection. The following section provides details of both the decision-making and recruitment processes.

3.2.1. Reason for Choosing Synaesthesia and Absolute Pitch

There is both anecdotal and empirical evidence that many composers and musicians throughout history have been synesthetes and/or AP possessors, suggesting a link

between these conditions and high musical achievement. This suggested link is further reinforced by the higher than normal prevalence of arts professionals within the synesthete and AP populations (see Chapter 2.1.6.: 'Synaesthesia and musical ability', and Chapter 2.2.2.: 'Prevalence of absolute pitch'), as well as evidence of a significantly higher prevalence of synaesthesia in populations of AP possessors (see Chapter 2.3.5.: 'Study 5'). Despite this, no research to date has systematically investigated the possible link between these two conditions. There is furthermore a lack of scientific investigation regarding synaesthesia and music, in contrast to the continual growth in research concerning more common forms of synaesthesia. Within the research literature, synaesthesia has been found to enhance memory skills, facilitate data organization, and be a source of creative inspiration (see Chapter 2.1.6.1.: 'Synaesthesia and memory'), and as such, the potential for synaesthesia to influence musical development, and expand conceptions of musical ability, is evident.

3.2.2. Ethics Clearance

Before undertaking the study, an ethics application was submitted to the Human Research Ethics at the University of Melbourne in July, 2013. Final ethics clearance was obtained on the 5th of September, 2013 (ID. 1340162), with data collection commencing in October, 2013. Plain Language Statements (PLS) and consent forms were prepared for use for the recruitment of participants. The main elements of the PLS given to students and members of staff comprised the following information:

- The project details, including the aims of the study.
- What participants would be asked to do, including the expected time commitment of each of the three tasks: online survey, interview, and test batteries.

- The voluntary nature of the study, and the possibility for participants to withdraw from the study at any time, with no consequence to their grades or relations with the University of Melbourne.
- Risk management strategies undertaken.
- The extent of anonymity provided, including the use of a pseudonym.
- The confidentiality of the data collected, and its long-term storage.
- Contact details for the Executive Officer of Human Research Ethics, and the University of Melbourne Counselling and Psychological Services.
- Contact details for both the Student Researcher and Responsible Researcher.

The annual report for this study was submitted on the 11th of December, 2013, with the study approved until the 31st of December, 2014. This approval was renewed annually until the 31st of December, 2018.

3.2.3. Sample Used in the Study

Participants were drawn from the population of staff and music students within the Melbourne Conservatorium of Music (MCM), the University of Melbourne (Australia). The MCM is the largest and most comprehensive music program in Australia, and a student population who are both musically skilled and intellectually distinguished.

3.2.3.1. Recruitment of sample.

An initial meeting was set up with the coordinator of Aural Studies 1 and 2 classes at the MCM, to discuss the study and solicit his help. This academic made an initial announcement concerning this study in Aural Studies 1 classes at the end of Semester

1, 2013. Students were given the student researcher's email address and asked to contact the researcher if interested in partaking in this study. This led to 34 positive responses of self-reported synaesthesia and/or AP, and an initial email contact was established with these students. While in the majority of the initial emails the students indicated which of the two conditions they had, or believed they had, there were three emails that expressed their interest in participating in the study, without specifying whether they were synesthetes or AP possessors. Eight of the students identified themselves as either synesthetes or AP possessors, but also indicated that they were unsure as to whether they had the other condition. Two academic staff members also expressed their interest in participating in this study, both of whom have self-reported AP. The distribution of these initial responses is provided in Table 3.1.

Table 3.1
Distribution of preliminary responses to announcements made by the coordinator of Aural Studies 1 and 2 classes

	Academic teaching staff	**Students**
Not specified		3
Synaesthesia		13
Absolute Pitch	2	18
Both conditions		*8*
Total	2	34

In order to identify any supplementary students who identified as synesthetes or AP possessors, the aural lecturer invited the researcher to make additional announcements during aural classes in the undergraduate music program during S2, 2013. The researcher attended Aural Studies 1 and Aural Studies 2 classes in October, 2013, to briefly discuss the study, and hand out plain language statements and consent forms to students who were interested in participating in the study. There were no new participants recruited as a result of this process. Of the 34 students who initially

expressed their interest in the study, 15 agreed to participate in the study, by signing the consent form.

After this initial sample was established, other participants were recruited through word-of-mouth. Students would contact the researcher, either via email or in person at the MCM, to enquire about the study. The researcher also made an announcement during the opening Postgraduate Seminar for 2014, and one postgraduate student with AP was recruited.

3.2.3.2. Final participant sample.

The final, total number of participants recruited was 35, consisting of 4 academic staff members, and 31 students (see Table 3.2). The researcher met students and staff members individually to discuss the study and what was required of participants. Participants were then given the Plain Language Statement to keep and were invited to fill out the Consent Form. This form was kept by the researcher and archived.

Table 3.2
Distribution of final number of participants, noting their condition(s)

	Academic teaching staff	**Students**	**Total**
Synaesthesia	1	17	**18**
Absolute Pitch	4	24	**28**
Both Conditions	1	10	**11**
Total	4	31	**35**

Of the 35 participants in this study, 18 have synaesthesia, 28 have a form of AP (see Section 3.3.3.2.5.: 'Scoring the absolute pitch test' below), and 11 have both conditions.

3.3. Measures and Procedure

Four forms of data collection were employed, comprising an online survey aimed at gathering background information to assist with the study, a semi-structured interview to identify cognitive, affective, and behavioural influences of synaesthesia and/or AP on musical development, and two test batteries which were used to measure, categorise, and confirm synaesthesia, and/or the possession of AP.

Each of the following sections outline the details of these data collection techniques together with the procedure adopted concerning how they were employed with the sample of participants studied.

3.3.1. The Research Survey

An analysis of the research literature was undertaken to identify information relevant to the development of synaesthesia and AP. Using this information, an online survey was devised to extend and clarify the findings obtained when analysing the data of the subsequent interview and test batteries. The information chosen for inclusion in the survey was selected after being identified in a review of the literature. Where necessary, information obtained from the survey was checked with the participant during the semi-structured interview that followed, to ensure the accuracy of the responses.

The online survey was developed using the MCM's license for PollDaddy. The estimated time to complete this survey was 15-20 minutes. Participants that had agreed to participate in this study were given a unique PollDaddy address and invited

via email to logon to the relevant site to complete it. A standard email was sent out to all participants (see Appendix B).

The survey comprises 40 questions and was designed around 4 main areas of particular interest to this study: demographic information, musical history, synaesthesia and AP, and medical history relative to these two conditions and any related conditions.

3.3.1.1. Demographic information.

The first section collected data on participants' demographic characteristics, including name, date of birth, gender, handedness, enrolment details at the MCM, and languages spoken. As discussed in the review of the literature in Chapter 2, studies show a strong relationship between early exposure to a tonal language and AP ability. Participants were therefore asked if English was their mother tongue, questioned on the languages they spoke, and asked which of these languages they spoke fluently before beginning school. All of the questions in this section were either multiple-choice questions, or free text answers. The response 'other' was added where appropriate, and space was given for participants to include remarks.

3.3.1.2. Musical history.

The second section focussed on questions relating to the participant's musical history. Based on literature summarised in Chapter 2, several theories relating to the genesis of AP ability were identified. Apart from a possible genetic cause, it is argued that intensive practice and early onset of musical training can both provide possible explanations as to the origin of AP ability. For this reason, participants were questioned on the age at which they began formal musical training, their primary

instrument or voice type, the number and types of instruments they play, which days of the week they practice and their average daily amount of practice, and results achieved in Australian Music Examination Board (AMEB) or Trinity examinations. Multiple-choice, number, and free text questions were used.

3.3.1.3. Absolute pitch and synaesthesia.

The third section concerned synaesthesia and AP. A brief description of both conditions was given before the questions on each condition were presented. Participants were first questioned as to whether they possess AP, whether other members of their family possess AP, who these family members are, and if they are twins. Participants were then asked for the same information in relation to synaesthesia. Participants could either answer yes, no, or unsure, to questions pertaining to having the conditions. For questions concerning family members, all first, second, and third generation family members were included in the multiple-choice responses, with the option of choosing 'other'. In relation to synaesthesia, participants were also asked what type or types of synaesthesia they experienced, and whether these sensations had always been present. The 63 types of synaesthesia known to date were listed, and participants who had indicated that they had synaesthesia were asked to place a tick in the box next to the type(s) of synaesthesia they experienced. They were given the option of either a 'yes' or 'unsure' response. If they were sure that they did not have a particular type, they were instructed to leave that type blank.

People with synaesthesia are often unaware of the fact that what they experience differs from normal perception, and that it is labelled 'synaesthesia'. For this reason,

all participants were asked to read through the list of *Types of Synaesthesia*, even if they did not believe they were synesthetes. If, after perusal of the list, they remained convinced they were not synesthetes, they were invited to move directly to the subsequent page. Again, for this question the option 'other' was added, so that participants could describe in detail any other experiences they thought might qualify as synesthetic. These remarks were then discussed during the one-on-one interview. Participants who indicated that they experienced at least one type of synaesthesia were asked if they had had these sensations for as long as they could remember. The rational for this was to differentiate between possible cases of idiopathic synaesthesia, and induced forms of synaesthesia. Idiopathic synaesthesia will generally manifest itself in the early years of childhood, with synesthetes reporting that their synesthetic percepts go back as far as they can remember. In comparison, induced forms of synaesthesia (such as induced by epilepsy or drug consumption) can manifest themselves at any developmental stage.

3.3.1.4. Medical history.

The fourth and final section was related to the medical history of the participants, with a specific focus on conditions known to either induce synaesthesia and/or AP, or where synaesthesia and AP have been demonstrated to occur more frequently within these populations. Participants were asked if they had ever suffered from seizures, if they had been diagnosed with epilepsy, an autism spectrum disorder, or if they had received treatment for another neurological condition or disorder. Participants were also asked the same questions regarding members of their families, and who those family members were.

3.3.1.5. Format of the online survey.

The opening page of the survey was headed by the University of Melbourne and Melbourne Conservatorium of Music logos, with an introduction including the contact details of the student researcher. Participants were then directed to the first section of the survey (see Appendix C).

The majority of the questions asked in this survey were mandatory, as participants were unable to proceed to the following sections without completing all of the questions. If they did skip a question, it would be marked in red, and the participant would be prompted to complete it. The fourth section relating to the medical history of the participants was, however, the only section to include questions that were not mandatory. In this section, participants were free to answer or not answer any of the questions they chose, without this affecting their ability to successfully complete the survey.

A full list of questions asked in the survey is provided in Appendix D.

3.3.2. The Interview

A qualitative research interview is a professional conversation that attempts to understand how the interviewee sees the world, and to reveal the meaning of his or her experiences (Kvale & Brinkmann, 2009). The research interview also serves to produce knowledge, whereby knowledge is constructed in the interaction between the interviewer and the interviewee. In this sense, knowledge is used to refer to both everyday knowing and systematically tested knowledge. The dual focus of the research interview is on both the personal interaction that occurs between the

interviewer and the interviewee, and on the knowledge constructed through that interaction.

Qualitative research methods are becoming common in many different fields of modern research (Kvale & Brinkmann, 2009). The stance taken by qualitative research diverges from the methodological or technical study of human lives, but instead focuses on the cultural and common aspects of how people understand themselves. As such, the qualitative interview seeks to reveal the lived world of the interviewee and how he or she thinks, learns, knows, and acts, prior to scientific explanations.

There are many types of interviews that can be employed for knowledge production, but for the purposes of this study it was decided to conduct semi-structured life world interviews. This type of interview is defined by Kvale and Brinkmann (2009) as "an interview with the purpose of obtaining descriptions of the life world of the interviewee in order to interpret the meaning of the described phenomena" (p. 3). As such, the life world interview is scripted, with a sequence of themes to be covered and suggested questions written out. The semi-structured nature of the interview, however, leaves place for an openness in the form and sequence of the questions asked, with the possibility of following-up and re-examining responses given by the interviewee (Spradley, 1979).

3.3.2.1. Producing knowledge through the interview.

The open structure of the life world interview described previously enables the interviewer to learn from the experiences of the interviewee, but can also pose

problems in the systematic planning of an interview study. While no standard procedure exists for conducting a qualitative research interview, this study follows the *Seven Stages of an Interview Inquiry,* as outlined by Kvale and Brinkmann (2009, p. 102):

1. Thematising.
2. Designing.
3. Interviewing.
4. Transcribing.
5. Analysing.
6. Verifying.
7. Reporting.

These seven stages provide a linear progression to the interview, from the initial ideas and themes to be explored, to the conclusions drawn and final report. The description of each of these seven stages will be undertaken temporally, and will be described in relation to the present study.

3.3.2.1.1. Thematising the interview.

This stage is the first of two pre-interview stages, and refers to the formulation of the research questions to be addressed during the interview, as well as the clarification of the themes to be investigated. There are two main purposes that the interview can have. First, an interview can be exploratory, with little pre-planned structure, and an open design. Here, an issue or problem would be introduced, and the responses of the interviewee would then be followed up in an attempt to gain new information about the topic. Second, an interview can be more structured, and can be used to test group differences. As the purpose of this study is to investigate the impact of synaesthesia

and AP on musical development, a more standardised sequence of questions is used here to compare between-subject differences within a group.

A conceptual and theoretical understanding of both synaesthesia and AP was necessary in order to establish the base on which new knowledge concerning these conditions could be added and integrated. The work undertaken in reviewing current literature concerning these two conditions and related conditions is thus an integral part of this pre-interview stage and constitutes a necessary means by which theoretical understanding is developed.

3.3.2.1.2. Designing the interview.

Based on the work undertaken in the first section, a methodologically well-controlled interview design was drawn up. This format was deemed necessary as few studies exist concerning the interaction of these two conditions, and results to date are inconclusive and lack a theoretical framework. Understanding of the complex relationship that exists between these two conditions therefore shaped the framework of the interview design in a substantial way.

Thirty-five music students and staff members from the MCM were interviewed individually about their experiences. This number was a compromise between obtaining a representative sample and the resources available for this study. In order to gain a more longitudinal perspective on the effects of these conditions on musical development, four staff members were included in this interview framework.

The interview design was divided into four main sections:

1. Health and wellbeing.
2. Drug consumption and medication.
3. Childhood and family.
4. Creativity and musicianship.

Within these four sections, a script in the form of an interview guide was prepared (see Appendix E for a full list of prepared questions). For the purposes of this study, a direct approach to the interview was adopted, with the interviewer explaining the purpose of the interview, and posing direct questions from the start.

3.3.2.1.2.1. Thematic and dynamic questions.

In preparation for undertaking the interviews, a variety of sources were consulted (Galletta, 2013; Kvale & Brinkmann, 2009; Mishler, 1986), and as previously discussed, it was decided to frame the interview process by following the *Seven Stages of an Interview Inquiry* outlined in Kvale and Brinkmann (2009). This process not only provided an authoritative overview, but also a sensible structure upon which to shape the required content. Interview questions were designed to fulfil two functions: the first was a thematic function, and involved the contribution to knowledge, while the second was a dynamic function, and involved the promotion of a lively interview interaction (Kvale & Brinkmann, 2009). The interview questions prepared within the script of this interview were dynamic questions, but were based on previously formulated thematic questions.

The purpose of the interviews was to engender spontaneous descriptions of the lived world of the interviewee relating to the interview subject. When determining the

thematic questions of the interviews, the theoretical conceptions of the research topic and subsequent analysis of the interviews were taken into consideration. These thematic questions were then dynamically framed to promote a positive interaction between the interviewer and the interviewee and to stimulate the conversation by inciting the interviewee to discuss their experiences and perceptions. The interview questions were therefore formulated to be short, easy to understand, and devoid of academic jargon. To promote understanding, certain concepts (such as synaesthesia and absolute pitch) were briefly described before questions pertaining to these concepts were asked, with the interviewee able to ask questions concerning these concepts if required.

3.3.2.1.2.2. Narrative interview form.

The focus of a narrative interview is on the interviewee's account of a meaningful series of events, relating to the subject of the interview, which have been experienced by the interviewee. Understanding interviews as narratives in this form emphasises the temporal, social, and meaning structures of the interview (Mishler, 1986). Mishler (1986, 1999) explains that narratives can be seen as a natural cognitive and linguistic form utilised by individuals to organise knowledge and meaning, and as such is a valid and valuable interview framework. For this study, and in keeping with the spontaneous nature of the interview design, a narrative approach to interviewing was adopted, with the initial interview question asking participants: "Try to remember as far back as you can. What is your very earliest memory of a synesthetic experience/of your absolute pitch?" (see Appendix E). This initial request concerning a specific episode of their lives invited the interviewees to discuss a specific life story, with the role of the interviewer becoming that of a listener. The role of the narrative

interviewer as listener requires the interviewer to abstain from interruptions, with questions being asked to either clarify the content of the narrative, or help the interviewee continue. The verbal and physical cues of the interviewer, such as questions, nods, smiles, and silences, enable the interviewer to become the co-producer of the narrative (Kvale & Brinkmann, 2009). This approach was adopted throughout the interviews.

3.3.2.1.3. Conducting the interview.

3.3.2.1.3.1. The interview stage.

The interviews were conducted in a private room at the Melbourne Conservatorium of Music (MCM), Parkville. The interviewer and interviewee sat across from each other at a table, and all windows and blinds were closed. The interviewer did not take notes, but the interview was recorded by two devices: an Apple iPhone 5 using the Voice Memos application supplied by Apple, and a Roland R-26 portable voice recorder. Any video recording done during the interview was obtained using the camera function of the Apple iPhone 5. A 'do not disturb' sign was placed on the door to the room, indicating that an interview was in progress. Before commencing the interview, the participant was offered a cup of tea or coffee, and if accepted, the interviewer would supply one for both herself and the interviewee. This was done to maximise conviviality and to draw focus to the personal interaction between the interviewer and the interviewee.

3.3.2.1.3.2. Briefing.

The interview was introduced by a briefing, which thanked the interviewees for their participation, and defined the broad topic for discussion. Participants were informed that the interview would be sound recorded, and that a video recorder could be used during the interview to capture specific instances of visual description given by the interviewee. Participants were asked their permission before such video recording was undertaken. During the briefing, participants were instructed to 'pass' any question they felt uncomfortable answering and were informed that they could take a break or rest whenever needed. Participants were also encouraged to speak to the University's Counselling and Psychological Services after the interview if they felt strong emotions, or wished to talk about the interview experience. This was an important point, and was subsequently reiterated at the end of the interview process, during the debriefing. Interviewees often experience strong emotions at the completion of an interview: these emotions may be due to tension or anxiety felt concerning the purpose or later use of the information disclosed during the interview, or interviewees may experience a feeling of emptiness due to the quantity and quality of the personal information divulged about his or her life, and this in the absence of any similar return from the part of the interviewer (Kvale & Brinkmann, 2009). While these emotional states are possible, a common result of the interview process is, however, that interviewees enjoyed talking freely to an attentive listener about subjects that they may not have talked about in such depth before, and perhaps obtained new insights into the subject area discussed, through a mutual sharing of information between the interviewer and the interviewee (Kvale & Brinkmann, 2009). The briefing was concluded by asking participants if they had any questions, before beginning the interview.

3.3.2.1.3.3. The interview.

The interview was conducted based on the interview guide developed during the second stage of this process, the 'designing of the interview'. As previously mentioned, the interview guide was used to help structure the course of the interview and facilitate between-subject observations. The order of the questions asked was, however, heavily dependent on the descriptions and information offered by the interviewee. As noted by Kvale and Brinkmann, "knowledge is created "inter" the points of view of the interviewer and the interviewee" (2009, p. 123), and greater importance was therefore given to the conversational form of the interview than to the systematic nature of the interview questions. Secondary questions were asked in response to the situational cues provided by the interviewee, enabling the verification of the responses given by the interviewee, and providing a greater depth of information to help answer the research questions.

3.3.2.1.3.4. Debriefing.

The interview was concluded by a debriefing, which began by acknowledging the completion of the interview, and asking interviewees if they had any further comments or questions concerning the subject. After any subsequent discussion, participants were thanked for their participation, and were again encouraged to contact the University's Counselling and Psychological Services if desired. The sound recorders were then switched off, and the interviewer and interviewees were given the opportunity to discuss the interview and its contents without being recorded. Permission was asked to report any new information discussed during the informal conversation following the interview. After the departure of the interviewee, the interviewer took the time to reflect on the interview and make general notes

concerning the immediate impression of the interview, including the body language, tone of voice, and general attitude of the interviewee.

3.3.2.1.4. Transcribing the interview.

This is the first of the post-interview stages and concerns the transformation of the interview in its oral form to a written text in the form of transcripts, which was subsequently analysed. Differences exist between oral and written language, and as such transcribing can be described as an interpretative process, translating from one narrative mode into another (Kvale & Brinkmann, 2009). This transformation from a live social interaction into a static written form leads to the loss of body gesture and voice inflection cues, and as such the transcripts are inherently decontextualized. The form of transcription chosen is therefore of prime importance, as the transcription process is in itself an initial analytic process.

There are several different styles of transcribing, including verbatim, linguistic, and literary styles. As linguistic analyses and psychological interpretations of, for example, anxiety or denial are less important for the purposes of this study, a literary transcribing style was adopted to highlight phrasing distinctions and facilitate the communication of the narrative constructed between the interviewer and the interviewee. Due to the natural differences between written and oral language styles, a verbatim transcription can appear as incoherent speech. This can lead to the unethical stigmatisation of the interviewee concerning their intellectual level, and for this reason a more fluid written style was considered more appropriate for publication purposes. A third party was paid to undertake the transcription process, following

guidelines provided by the University of Melbourne, with all transcripts being subsequently verified by the researcher against the auditory recording.

3.3.2.1.5. Analysing.

There are different modes of interview analysis that focus on distinctive approaches, which consider either the meaning or linguistic form of the transcripts, or more general analyses, such as the bricolage form or theoretical reading form (Kvale & Brinkmann, 2009). These different modes of interview analysis are relevant to particular types of interviews. When considering the narrative approach employed in the design and execution of the interviews in this study, an eclectic bricolage form was deemed the most suitable method for the analysis of the transcripts.

3.3.2.1.5.1. Bricolage form of interview analysis.

Bricolage is the term used to describe a form of interview analysis that uses, and moves freely between, a mixture of ad hoc techniques and conceptual approaches to generate meaning from a large body of transcripts. This is a common form of interview analysis, which differentiates itself from more systematic analytical techniques such as coding and categorisation (Kvale & Brinkmann, 2009, p. 233). The researcher begins this form of analysis by reading through each interview in full to obtain an overall impression, before analysing in greater detail specific passages and statements. The categorisation of long interview statements can be employed to reduce them to simple categories. These categories can then be used to gauge the strength of an opinion relating to the category, which can be indicated using a numerical scale system. This can be done to facilitate the comparison of large amounts of transcripts while providing an overview of the data collected. Meaning

generated from these sections can be portrayed in words, numbers, figures, charts, or by employing a combination of these.

A list of ad hoc methods for qualitative data analysis was compiled by Miles and Huberman (1994), and included techniques such as noting patterns and themes, clustering, counting, noting relations between variables, and finding intervening variables (pp. 245-246). These techniques can be used, among others, to generate meaning in qualitative texts, although the techniques chosen should be used to arrange the information from the descriptive to the explanatory, and from the concrete to the more conceptual and abstract (Kvale & Brinkmann, 2009). For this study, a bricolage of mixed methods was applied to investigate the connection between synaesthesia, absolute pitch, and musical development.

3.3.2.1.6. Verifying.

After the analytical stage, the validity, reliability, and generalisability of the interview findings needed to be ascertained (Kvale & Brinkmann, 2009).

3.3.2.1.6.1. Validity.

Validity pertains to whether an interview study investigated what was intended to be investigated (Boyle & Radocy, 1987). Validity is not only a separate stage of the interview process, but also permeates the entire research process (Kvale & Brinkmann, 2009). In this way, the continual emphasis on validation techniques throughout the interview process lends strength to the overall validity of the research findings.

Research interviews are commonly criticised for not producing valid results, as the reports of the interviewees may be false. Test batteries were undertaken by the participants after the interview was completed to validate the perceptual qualities of the interviewees' experiences. Participants were aware of the test battery component of the research process before the commencement of the interviews, and it is suggested that this understanding can be used as a verifiable measure of validity.

3.3.2.1.6.2. Reliability.

Reliability pertains to the consistency and trustworthiness of the research findings (Kvale & Brinkmann, 2009, p. 245). One indication of reliability is the consistency of the responses of the interviewee during the interview. This can be measured by the interviewer during the interview, with the interviewer attempting to verify the participant's answers by asking secondary questions at various stages of the interview. The responses obtained can be subsequently verified.

3.3.2.1.6.3. Generalisability.

Once the findings obtained have been deemed valid and reliable, the generalisability of the findings can be addressed. Questions that need to be asked include whether the sample size is sufficient to enable generalisation, whether the emphasis should be on seeking universal laws of behaviour within the study's subgroups or on the uniqueness of the individual person, or whether there even exists the necessity to generalise. These questions will be addressed during the analysis and discussion of the data collected, whereby the transferability of the interview findings will be argued (see Chapter 8: 'Discussion').

3.3.2.1.7. Reporting.

The dilemma of interview reporting consists of choosing to present the data in a captivating and engaging manner, or in a scientifically documented and controllable form (Kvale & Brinkmann, 2009). Ideally, the final interview report would incorporate aspects from both of these, by presenting a rigorous, but readable and expressive, text.

3.3.2.1.7.1. Ethical reporting.

The ethical responsibility of the author is an important principle in interview reporting. The author in the case of the written interview narrative is not only speaking for him or herself, but also for the interviewees. To address this issue, ethical guidelines concerning informed consent, confidentiality, and consequences, were respected. First, written consent was required of all participants, who were given a clear understanding of the later use and possible forms of publication of data collected during the interview. Second, to protect the privacy and anonymity of the participants, they were informed that a pseudonym would be used at all times. The final guideline addressed was that of the anticipation of the possible consequences of the interview report. While it is difficult to anticipate all potential ethical consequences, the decision to change or not change a report based on these consequences was made on a case-by-case basis, keeping in mind the intended purpose of the study.

3.3.2.1.7.2. The final report.

In discussing the interview report as an end product of a long process, Kvale and Brinkmann (2009) observe, “working toward the final report from the start of an

interview inquiry may contribute to a readable report of methodologically well-substantiated and interesting findings" (p. 275). This theme of viewing the interview process globally, whereby each of the seven steps, from the initial theme design to the final reporting, are taken into consideration at each step, is an underlying theme of this interview procedure. The end product, in the form of a captivating and scientifically sound interview report, was kept in sight from the beginning of this procedure.

3.3.2.1.7.3. Structuring the interview report.

A standard format for reporting interviews would incorporate four key sections – introduction, method, results, and discussion (Kvale & Brinkmann, 2009). For the purposes of this thesis, the introduction and methodology sections were abridged within the interview report, as they are addressed in the first and present chapters. In the results section, selected quotes are highlighted to present the reader with an overview of the interview content and demonstrate the personal interaction between the interviewer and the interviewee.

Statements provided by participants described experiences that are ongoing due to the continuous presence of synaesthesia and AP in their everyday lives. General statements concerning their conditions are therefore conveyed using the present tense. In contrast, references to specific past events are recounted using the past tense. These quotes are presented within a frame of reference, to contextualise them, and enable a thorough understanding of their interpretation. The discussion of the data collected forms an integral part of the interview report, with an equilibrium between quotes and text being respected, to produce a balanced and fluid final text.

3.3.2.2. Key points.

Semi-structured life world interviews were conducted during this study, with the interview process framed by following the *Seven Stages of an Interview Inquiry* (Kvale & Brinkmann, 2009). The linear progression of these stages enabled a methodologically rigorous unfolding of the interview process, which was enhanced by the global view of the process, where the validity and reliability of each step was questioned, and the end report anticipated from the outset.

Qualitative research interviewing is a valid method to describe the life world of human subjects. Research interviewing can therefore be classified as a knowledge producing activity, through the interaction of the interviewer and the interviewee. This interaction constructs meaning, which is again restructured throughout the later stages of the interview process. During the interviews, interviewees were encouraged to narrate their experiences, and this narrative approach was continued through the analysis stage, and into the final report.

3.3.3. Synaesthesia and Absolute Pitch Test Batteries

3.3.3.1. Synaesthesia test battery.

Synaesthesia research gained momentum in the 1980s, although no single protocol for comparing and contrasting the synesthetes examined by these studies, no quantifiable scoring system, and no standard phrasing of questions was available to researchers at that time. In 2006, Eagleman and colleagues devised *The Synesthesia Test* to remedy this deficit. This unified collection of tests, which includes a survey and several online

software programs is freely available online at http://www.synesthete.org (Eagleman et al., 2007). The test battery can be used by both individual synesthetes and also by researchers, with participants given the option of entering a researcher's email address as well as their own in a specifically marked section, allowing them to privately share their test results with only that researcher. Through this mechanism, the invited researcher can immediately access the quantified results of each of the participants of his or her study.

Not only does this battery of tests provide a standard and unified testing alternative for researchers, it also allows for the comparison and pooling of data across laboratories worldwide, enabling faster scientific progress.

3.3.3.1.1. Reliability and validity of the synaesthesia test battery.

The consistency of synesthetic percepts is one of the defining characteristics of synaesthesia (see Chapter 2.1.3.: 'Diagnosing idiopathic synaesthesia'). It also provides researchers with a testing tool that has been in use for almost a century, and was subsequently used within this test battery as a means of differentiating synesthetes from non-synesthetes (Eagleman et al., 2007). Genuineness of synesthetic experiences was therefore verified by means of a test of consistency, where participants were asked to match concurrents to inducers (for example, colours to graphemes in the case of a participant with grapheme→colour synaesthesia). This task was repeated three times in a randomised manner for each form of experienced synaesthesia (for example, again in the case of a participant with grapheme→colour synaesthesia, each grapheme would be shown on three separate and spaced-out occasions to the participant, who would be instructed to match the grapheme with its

synesthetic colour concurrent). As such, this test battery examines the difference in colour choices (or other concurrent) across the three separate trials (Eagleman et al., 2007). Researchers also have the option of reinviting participants to sit the test a second time at a later date. This method is therefore an internal consistency task, whereby responses can be tested for consistency not only within a single session, but also after a significant time delay (Eagleman et al., 2007). The consistency with which this test battery measures the synesthetic concurrents of synesthete participants is an indication of the test's reliability, and this test battery has been demonstrated as a valid measure of synaesthesia.

Because of technological limitations, it is impossible at this point in time to test for certain types of synaesthesia online (for e.g., types of synaesthesia that incorporate taste, smell, orgasm, or tactile sensations). As all except one auto-diagnosed synesthete in this study had at least one type of testable synaesthesia, either grapheme or sound induced, the online synaesthesia test available at www.synesthete.org (Eagleman et al., 2007) remained a valid testing option for the purposes of this study.

3.3.3.1.2. Administering the synaesthesia test.

After the termination of each individual interview between the researcher and the participant, the researcher sent an email to each participant with auto-diagnosed synaesthesia, inviting the participant to complete the online synaesthesia test battery (see Appendix F). The participant then completed the test battery at a time that was most convenient for him or her, using the participant's personal computer. The researcher was sent an automatic email reply from the synesthete.org website once the

participant had successfully completed the test battery, inviting the researcher to view the participants' test results.

3.3.3.2. Absolute pitch test battery.

The previous section discussed why *The Synesthesia Test* is a clear and thorough option for diagnosing and categorising the synesthetes evaluated in this study. There existed, however, the need for a similarly rigorous test for AP to be developed for the purposes of this study.

As indicated in Chapter 2.2.1. ('Definition of absolute pitch'), AP is defined as the ability to label or produce a note of a given pitch in the absence of a reference note (Deutsch, 2013; Takeuchi & Hulse, 1993). Based on evidence from neuro-imaging and electrophysiological evidence (Zatorre et al., 1998), AP is conceived of as an ability to associate pitches with meaningful labels, with these relationships being stored and accessed in long-term memory. Absolute pitch is not, however, an all-or-nothing phenomenon, and is characterised by different levels of recognition accuracy; as such, AP can be described as lying along a continuum (Bermudez & Zatorre, 2009; Deutsch, 2013; Deutsch, Dooley, et al., 2009). Consequently, in order to evaluate this ability, it was necessary to construct items in which participants were asked to label pitches in various test situations of increasing difficulty to be able to identify where on the AP continuum each participant could be placed. What was important for the aims of this study was not only the classification of the participants as AP possessors, but the placement of each of them in an ascending order of AP ability.

To examine individual participant's ability to label pitch classes in various aural situations, a *Test of Absolute Pitch* was constructed. The development of this test

focussed on three aspects of content validity:

- The range and scope of possible test items.
- The suitability of these items for use with advanced level music students and professional musicians.
- The accuracy with which these items measured the full range of a participant's AP abilities.

The development of this test battery was undertaken during the two-month period preceding the main study.

3.3.3.2.1. Pitch labelling.

Research into the literature on quantifying AP abilities demonstrates that there are several methodologies used, but all generally use either pitch identification or production (Takeuchi & Hulse, 1993). Identification tasks involve presenting participants with a note and asking them to identify it. Production tasks, on the other hand, typically involve matching a participant's aurally presented and recorded tone with the correct tone during the analysis of the data. Production tasks are used less frequently than identification tasks, and for the purposes of this study pitch production tasks were ruled out from the outset for two main reasons. First, it has been previously noted that not all participants that are able to correctly identify pitches are able to produce them with the same level of accuracy, while the inverse has yet to be seen (Dooley, 2011). The focal element of this study's examination of AP lies in the investigation of AP's perceptual qualities, and thus identification tasks were deemed the more appropriate option. The second reason was a practical one, as oral data collecting and analysing from all participants would have been an impractical task with no real foreseeable benefits relating to the measurement of a participant's AP

abilities.

In order to assess the level of AP demonstrated by the participants of this study, a test battery consisting of three separate measures was devised: note labelling with piano tones, note labelling with pure tones, and note labelling within chords.

3.3.3.2.2. Quantifying absolute pitch ability.

Not all AP possessors name pitch accurately regardless of how the pitch is produced (Deutsch, 2013). While some AP possessors are able to name pitches produced through a wide variety of sources, such as car horns, birdsong, machines, or peoples' voices, others are only able to do so for specific and familiar instrument timbres. Research has demonstrated that piano timbres are particularly conductive to high levels of correct note labelling (Athos et al., 2007; Baharloo et al., 1998; Takeuchi & Hulse, 1993; W. D. Ward, 1999). In a large-scale study, Lee and Lee (2010) found a strong effect of timbre on the accuracy of note identification, with accuracy being highest for piano tones and lowest for pure tones. For this reason, both piano and pure tones were chosen to be included in this test, to separate between differing levels of AP possession, and to investigate what this might reveal about AP ability in general. During the interview stage of this study, participants with auto-diagnosed AP were asked to describe their particular AP abilities, including the effect of timbre on their ability to successfully label pitches. Using both piano and pure tones allows this information to be consolidated, and the personal reports of the interviews verified with empirical data.

3.3.3.2.2.1. Piano tones stimuli.

The first task was developed to measure the recognition accuracy of piano tones. The use of piano tones can be justified for two reasons. First, piano tones are used to provide a contrast to the subsequent pure tone task in this study, as research has demonstrated that variability in the expression of AP ability can be detected by using piano tones (Wilson et al., 2012; Wilson et al., 2009). Second, the timbre of the piano is highly familiar to the participants in this study, and represents both past and present musical environments, allowing for the exploration of the relative contribution of these environmental factors (Wilson et al., 2012). This task was modelled on previous tests by Baharloo and colleagues (1998), Deutsch and colleagues (Deutsch, Dooley, et al., 2009; Deutsch et al., 2006), and Wilson and colleagues (Wilson et al., 2012; Wilson et al., 2009). For this study, the participants were presented with a set of 36 notes spanning a three-octave range between C3 (131Hz) and B5 (988Hz). The stimuli were piano tones generated on a synthesiser tuned to A4 = 440Hz. The lowest and highest octaves of the piano were omitted. Tones were played in a pseudorandom order, but in order to minimize the use of relative pitch as an aide, successive tones were separated by an interval larger than an octave. The tones were digitally recorded and edited to have uniform durations of 500ms, with 2.5s response time between tones (1 stimulus = 3s). Because of the automatic nature of absolute pitch, AP possessors are not only more accurate, but are also much faster at pitch identification than RP possessors (Dooley, 2011). The response time was therefore kept short to minimize accurate pitch naming based on relative pitch judgments (Wilson et al., 2012).

3.3.3.2.2.2. Pure tones stimuli.

The second task was developed to measure the recognition accuracy of pure tones.

This task was identical to the precedent task in number and duration, although the ordering of tones was different. Pure tones were digitally synthesized. Tones of different frequencies were synthesized with different amplitudes, to equalize perceived loudness. Sine-wave tones had frequencies corresponding to the 36 musical notes from C3 to B5, on the basis of A4 = 440Hz. Each tone had a duration of 500ms, with 2.5s response time between tones (1 stimulus = 3s).

3.3.3.2.2.3. Chordal stimuli.

The two tasks noted above (piano tones and pure tones) were developed to diagnose AP ability. As an added measure of complexity, however, a further 9 tasks were devised, consisting of simultaneous tones incorporated in groupings of 2 to 7 tones. These additional tasks (tasks 3-11) are non-diagnostic, but were included based on preliminary discussions with AP possessors during the interview stage of the study. These tasks furthermore add an extra layer of musical authenticity, given that most music people listen to is composed of simultaneous tones.

The nine supplementary tasks were developed to measure the recognition accuracy of tones within chordal structures. During the interview process, participants with auto-diagnosed AP were questioned on their perceived ability to successfully label pitches when these pitches were placed within chords or clusters. The participant responses varied greatly, and it was decided to test these suppositions through the elaboration of chordal stimuli tasks. To complement the two diagnostic tasks (task 1: piano tones, and task 2: pure tones), nine different conditions within these supplementary tasks were developed:

3. Label the base (bottom) note (of a 2 note interval)
4. Label the highest (top) note (of a 2 note interval)
5. Label the middle note (of 3)
6. Label the 2 outer notes (of 3)
7. Label the 2 outer notes (of 4)
8. Label the 2 inner notes (of 4)
9. Label all 5 notes (of a 5 note chord)
10. Label all 6 notes (of a 6 note chord)
11. Label all 7 notes (of a 7 note chord)

In tasks 3-8, six different intervals or clusters were presented to participants. For tasks 9-11, only one chord was presented for each tasks.

The rationale behind these measures was to examine the level of interference that juxtaposed pitch information could have on pitch labelling ability. To our knowledge, AP ability has not been empirically tested under these conditions before.

3.3.3.2.3. Administering the absolute pitch test battery.

Eleven tests were administered to each participant. The first two tasks consisted of 36 piano and 36 pure tones, respectively. A further nine tasks incorporating chordal stimuli were subsequently administered to each participant. The first two tests were divided into three blocks, with 12 trials in each block and 5s pauses between blocks. Participants listened to the tones through headphones and were asked to make an instantaneous judgment of the pitch of each tone. Participants were not given any practice runs, and feedback regarding their performance was not provided at any time during the tests.

Tests 3-11 were divided into nine blocks, with 5s intervals between each block.

Participants listened to the intervals or chords through headphones and were asked to make an instantaneous judgment of the relevant notes, according to the specifications of each task. Participants were not given any practice runs, and again feedback regarding their performance was not given at any time during the tests.

3.3.3.2.4. Response type.

Several different response types used in standard pitch identification tasks have been documented, including pointing to the corresponding key on a piano, clicking on a pitch class wheel during an online test, picking out a specific pitch amongst many alternatives, identifying both note name and octave, or simply naming the pitch class (Bachem, 1937; Cuddy, 1968; Lockhead & Byrd, 1981; Miyazaki, 1988; W. D. Ward, 1999). The most appropriate response type for this study was chosen after careful consideration of these five methods.

3.3.3.2.4.1. Pointing to the piano.

Pitch identification can be achieved by instructing participants to either point to the corresponding note on a piano, or to silently press individual notes down on a keyboard linked to a computer, which would register the response, without providing aural feedback to the participant. There have been, however, anecdotal accounts that the sensory or contextual cues in physically holding or viewing a familiar musical instrument are sufficient to enable the retrieval of otherwise inaccessible long-term pitch memories (Dooley, 2011). As instrument familiarity was deemed to be a potential influence on pitch identification ability, this method was not retained.

3.3.3.2.4.2. Pitch-class wheel.

One method that was carefully considered for this study was to develop an on-screen pitch-class wheel, with participants instructed to move the cursor and click on the pitch-class corresponding to the pitch they had been presented with. In this model, a circular design moving chromatically through the 12 pitch-classes, and starting with 'C' at the top, would have been developed. While this is an attractive, auto-registering solution, it was deemed impractical, as participants would be required to locate the pitch-class after its identification. This was seen as a possible time-consuming exercise, which may have led certain participants to fail to register correct responses in time. There was also the added risk of participants clicking on the wrong pitch-classes through a lack of technical ability, or physical fault. For these reasons this method was not retained.

3.3.3.2.4.3. Pitch identification among alternatives.

A further alternative is to align the 12 chromatic tones by their pitch-class names (C, C#, D, D#, etc.) for each trial, and ask participants to circle the name that corresponded to the tone they are presented with. This method, however, shares the same impracticalities as the previous two methods. Not only is there the requirement of locating the pitch-class after its identification, which may slow down response time, but there also exists the possibility that the layout of the chromatic scale in an ascending order may provide contextual cues to the participants, again enabling the retrieval of otherwise inaccessible long-term pitch memories (Dooley, 2011).

3.3.3.2.4.4. Identifying name and octave.

Labelling both pitch name and octave placement of tones can generate an unnecessary difficulty in pitch identification. A number of studies have shown that octave errors

are common in pitch identification tasks, even when correct note name identification has occurred (Bachem, 1955; Lockhead & Byrd, 1981; Miyazaki, 1989). Octave errors may be due to a lack of standard terminology for designating octaves, or to the differences in perceived height that can occur when tones are built on the same fundamental, but played on different instruments (Deutsch, 2013). As demonstrated by Wilson and colleagues (2009), correct pitch identification does not require accurate octave classification. Consequently, there was no foreseeable advantage in asking participants to specify octave placement, and it was therefore decided that this was an unnecessary parameter to add to the test.

3.3.3.2.4.5. Identifying pitch class.

Identifying and manually writing the name of the presented pitch on a sheet of paper is the simplest and most efficient method of pitch identification. In contrast to octave identification, music theory provides universally recognized and accepted labels for pitch class (C, C#, D, D#, etc.). What distinguishes AP possessors from non-possessors is their ability to recognize and label pitches (Bachem, 1955; Miyazaki, 1989). The researcher therefore asked participants to write the name of the presented pitch on a numbered sheet of paper, providing the most informative method of assessing pitch identification. This is in keeping with AP tests used by Deutsch and colleagues (Deutsch, Dooley, et al., 2009; Deutsch et al., 2006). This method is straightforward, it provides security against technical errors, and is the least likely to be subject to exterior influences. For these reasons this method was retained for the AP test battery (see Appendix G, which provides an example of the copy sheets given to participants to fill in).

3.3.3.2.5. Scoring the absolute pitch test.

The scoring of the AP test was modelled after Wilson and colleagues (2012; see Chapter 2.2.3.: 'Diagnosis of absolute pitch'). For each participant, correct responses were given one mark, and the final number of correct responses for each task was recorded. Enharmonically equivalent notes, such as D# and Eb, were scored as correct, and participants were therefore able to choose the pitch label they preferred, when presented with accidentals. Participants were subsequently sent a breakdown of their scores via email, but were not, however, sent a copy of the correct responses. This was done to ensure that no possible circulation of the correct responses between participants was possible.

To be classified as an AP possessor, a participant needed to obtain a total number of correct responses above 80%, for both piano and pure tone tasks. For quasi-AP (QAP) classification, scores needed to fall between 20-80% correct. All participants who obtained accumulated scores under 20% were considered to be non-AP possessors, and were therefore classified as relative pitch (RP) possessors. Although weaker, QAP is regarded as a form of AP. As this study is primarily concerned with the lived-world experiences of possessors, and not their level of AP ability, both AP and QAP possessors are treated equally within the analyses of the following results chapters, and subsequent discussion of these results.

3.4. Organisation of Results Chapters 4-7

In order to respond to the two research aims of this study, the following four chapters report on the results obtained within this study. These four chapters will be divided according to the two main aims:

1. Aim 1 is to identify the degree to which synaesthesia and/or AP possession may facilitate or impair the cognitive, affective, and behavioural outcomes of musical development. To organise the data collected, a cognitive, affective, and behavioural framework was implemented, which governed all of the procedures of the survey instruments. Many of the results obtained contain elements that could be categorised under several outcomes. While classifying these results was challenging, it was ultimately decided to highlight them under the heading (cognition, affect, or behaviour) that represented their catalyst. Reporting on other related outcomes could also be incorporated. As such, three results chapter are dedicated to addressing the first research aim. These three chapters are organised according to the results obtained under the headings: cognition, affect, and behaviour (Chapters 4-6).
2. Aim 2 is to investigate the potential interaction between synaesthesia and AP. A fourth results chapter is therefore dedicated to a comparative analysis of synaesthesia and AP (Chapter 7).

The data provided in these results chapters are reported in a narrative style and based on the self-reports of participants in this study. They are supported by descriptive statistics gained from the quantitative analysis of the interview questions, online survey, and synaesthesia and AP test batteries. A selection of representative quotes is provided within each subsection. This selection is non-exhaustive but has been chosen to highlight the theoretical analysis of the data.

A tabulation of the names and condition(s) of all quoted participants is provided at the commencement of each results section. These tables are included to promote a fluid analysis of the ensuing passages, and to assist in their examination. The participants in each table are ordered by condition(s), with participants with both conditions appearing first, followed by synesthetes, and terminating with AP possessors. Furthermore, a synopsis of each participant is provided in Appendix A, in order to provide supplementary information concerning each participant who participated in the study.

The results obtained in this study have been categorised under four chapter headings: 'Chapter 4: Cognition', 'Chapter 5: Affect', 'Chapter 6: Behaviour', and 'Chapter 7: Idiopathic Synaesthesia and Absolute Pitch: Interactions and Comparisons'. As such, the following results chapter (Chapter 4: Cognition) reports on the cognitive outcomes of synaesthesia and AP on musical development.

Chapter 4

Cognition

In what ways does the possession of synaesthesia or absolute pitch (AP) impact the cognitive outcomes of musical development? This broad question forms the basis of this chapter, in which two cognitive domains – memory and imagery - are examined. These two domains were selected based on a review of the current literature concerning synaesthesia and AP, and on data obtained from the self-reports of participants in this study.

In the first section of this chapter, the impact of synaesthesia and AP on music memorisation is investigated. First, the potential for synesthetic percepts to act as mnemonic and structural cues, and to assist a possessor's ability to overcome memory lapses and difficulties in music recall, is examined. Second, AP associations are similarly assessed in relation to their potential role as mnemonic, structural, and music recall aids. Importantly, this subsection concerning AP additionally investigates the role of AP in increasing music memorisation speed and culminates in an analysis of specific reports from AP possessors concerning the development of a pitch-classification system involving a memorised bank of sounds.

The second section of this chapter investigates the impact of synaesthesia and AP on auditory and visual imagery (AI and VI). The section begins with an investigation of the potential for synaesthesia and AP to enhance AI. The influence of AP on AI, and the resulting musical benefits, are subsequently examined, as is the functional relationship between AI and synaesthesia. Furthermore, this section reports on unexpected data collected during this study concerning cases of involuntary complex visual imagery (CVI). Case study analyses are undertaken in order to consider the role of synaesthesia and AP in these examples.

4.1. Memory

"Whenever I memorise music…[AP] is like the flame behind the steam engine, I feel. It's always there and I sort of need it."

Alexander (AP)

In the analyses that follow, synaesthesia and AP are examined separately in relation to their relationship with musical memorisation.

One domain that is well studied in relation to non-music related forms of synaesthesia is memory, which is why it is important to begin with this literature and possible parallels with music memorisation. The potentiality for synesthetic percepts to be used as mnemonic and structural aids, and their ability to help synesthetes overcome difficulties in music recall, are investigated through an analysis of the perceptual and cognitive experiences of these synesthetes, and their impressions of the role these conditions play in the structuring and organisation of their musical memories.

Next, the role of AP in music memorisation tasks is similarly addressed in the ensuing analyses. These analyses include the utilisation of AP as mnemonic and structural cues, and the potential for AP to aid possessors overcome difficulties in music recall. Furthermore, the effect of AP on the speed of memory acquisition is discussed, and a case study of the potentially negatively impact of AP on music memorisation presented. This section concludes with a review of three case studies outlining the development of a 'sound bank' of memorised musical excerpts.

In this study, all 35 participants noted an effect of their synaesthesia and/or AP on their music memorisation. Of these, 28 participants (80%) noted a strong positive influence, while six (17.1%) noted a weak positive influence. Only one participant (2.9%) – Cooper – indicated his AP potentially hindered his music memorisation. Cooper's unique case is discussed in more detail in Section 4.1.2.3.1. ('Cooper: Short-term memory deficiency and AP') of this chapter. In total 34 participants (97.1%) reported their condition(s) enhanced their music memorisation abilities with all participants noting an effect on their music memorisation due to at least one of the two conditions. This overwhelmingly positive effect strengthens the rationale for investigating this link further.

4.1.1. Synaesthesia

"I would memorise the colours. Yeah, memorising notes - I feel like I just can't do it."

Charlotte (Synaesthesia)

Synaesthesia was reported as enhancing music memorisation, through the use of synesthetic percepts as mnemonic and structural cues, and through the employment of synesthetic percepts in overcoming memory lapses, particularly in performance situations.

4.1.1.1. Synaesthesia as a mnemonic aid.

Name	***Condition(s)***
Charlotte	Synaesthesia
Isabella	Synaesthesia

Synesthetes reported actively using their synesthetic percepts to aid in their music memorisation, thus providing them with a mnemonic advantage. Charlotte, for example, described utilising the specific colours and images she perceives as a mnemonic aid, stating: "I always wondered why I could remember tunes and lyrics and things like that so well. Now I realise that I listen to songs and they're all specific colours and things like that, and pictures…otherwise I'm a terrible memoriser. When I'd focus more on the colours, it was a lot – a lot - easier." When asked whether she would memorise the colours, or actively memorise the music, Charlotte elaborated as follows:

> CHARLOTTE: I would memorise the colours…Yeah. Yeah, memorising notes - I feel like I just can't do it. I can feel when I don't know a piece very well. It is just notes. I'm not seeing anything. When I learn a piece well or I've memorised it well, it is all colours. It's like I get a clear idea of exactly what it looks like in my head.

Charlotte's reflections demonstrate an intimate link and even dependency on synesthetic percepts for memorisation tasks. This strategy is advantageous, as she herself acknowledged having an excellent memory for music. For Charlotte, her performance of a memorised piece is directed by her synesthetic colour percepts:

> CHARLOTTE: …If I'm trying to remember something and I'm quite familiar with the sound of a piece, then I remember it in colours. It's almost like my fingers move because of the colours rather than my fingers move because I can remember what the notes are, if that makes sense.

Music memorisation is thus heavily reliant on Charlotte's accompanying synesthetic colour percepts. What is more, synesthetic concurrents are memorised in priority to, and better than, the original (music) inducer. When a piece is familiar, its recollection is thus adapted from an auditory to a visual mapping of the piece.

The use of sound-related forms of synaesthesia as a mnemonic aid was similarly noted by Isabella: "It does affect my memory of pieces on piano when I've memorised them. It's just connected. It's like, "What are the first notes?" It's the colour." Isabella appeared somewhat surprised, however, by the subconscious nature of the perceived effects, admitting that it was the interview questions she was asked that drew the extent of this effect to her awareness:

> ISABELLA: It's so subconscious. I don't even realise…I can't imagine if everything was just black and white. I just can't imagine that because then there'd be nothing to help you [laughs]. Yeah, I just never thought of that

before [laughs]. I just assumed until high school that everyone had it which was dumb but you don't really question it. It's so subconscious that you don't really question it.

It is not only music→colour synaesthesia, however, that can confer advantages on music-related tasks. As a grapheme→colour synesthete, Isabella recounted a recent orchestration exam that she undertook, where she was obliged to memorise all of the instrument ranges. She learnt these by their note names: D to C, or G to D etc. These letters were accompanied by colours, and this colour association was an important mnemonic aid for this task. Isabella gave the example of the piccolo range, which started on D, and which was "so strongly red that I just knew it because it was red. So, I did use that colour to help me remember it, for sure, because it was the middle D as well [laughs]."

The above examples demonstrate that synesthetes are able to harness their unique associative responses to music, as well as transfer associations from other sequence-induced forms of synaesthesia, to aide in their recall of music and to facilitate specific music related tasks.

4.1.1.2. Synaesthesia as a structural cue.

Name	***Condition(s)***
Lily	Synaesthesia

A further extension of the application of synaesthesia in music memorisation tasks is through the use of percepts to provide structural markers to aide in the organisation of memory. Lily described this process occurring in two distinct ways, which were

nonetheless both reliant on her grapheme→colour synaesthesia: first, with intervals and their corresponding – numerically based - colours, and second, by recalling the colours of individual notes, which are prescribed colours based on their corresponding letter name. Thus A, A flat and A sharp all have the same induced colour (yellow). Notes can also be assigned colours based on their intervallic relationship with other prominent notes. For Lily, both B and B flat are red, as they are a fifth above E (the number 5 being red). This is of particular interest, as the letter B for Lily is green; in a musical context, however, it is red. In this situation it is the intervallic relationship that primes over the letter name. Indeed, Lily clearly asserted this when asked which was of greater importance:

> LILY: Probably intervals because being a cellist and a singer, I use intervals more to find the notes. And I use intervals to tune within a chord because I'm [pauses] an ensemble player. Even when I'm a soloist, intervals more than anything. But I might use the letters mapped to the stave and those colours to recall at the start of a tune how the tune goes, what the tonic is and how to find my first note against that: how to find the opening phrase.

The percepts Lily sees for intervals and notes appear to function at different levels and accomplish different roles. Her intervallic percepts – based on numbers – work as scaffolds, and aid in her sight-reading, sight-singing, transcribing, improvising, and tuning within a chord. The colours she sees for individual notes act as structural markers, which enables her to map out the tonic and any other distinguishing points, and aid in her recollection of the opening of a musical phrase (see Figure 4.1). In this way, vertical mnemonic aids act as scaffolds (vertically layering colours through

intervallic relationships), while horizontal mnemonic aides act as structural markers (using the colours of individual notes as structural 'bricks' along the temporal, sonic 'wall').

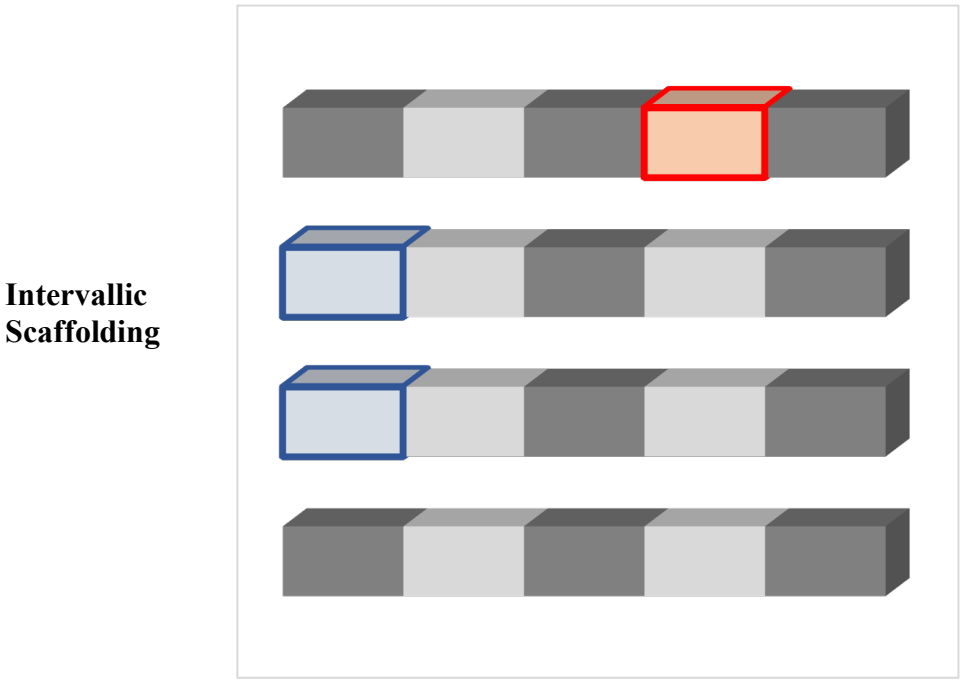

Figure 4.1. Two related aspects of grapheme→colour synaesthesia interact in music memorisation tasks in the case of Lily. First, intervals induce synesthetic colours based on their interval number, and act as mnemonic scaffolds; second, individual notes induce synesthetic colours based on their alphabetic label, and act as structural markers.

The transferal of the colour of a letter onto the read or heard (corresponding) note does not apply, however, when thinking of the tonality of a piece. Even if Lily is aware of the tonality of a piece, she does not perceive an overarching colour, but instead perceives and hears the movement of the harmony. While this is again an intervallic perception, it does grow in complexity from mere single intervals. For example, Lily perceives dominant chords as "red and purple", as they are built up of the fifth (5=red) and flat seventh (7=purple) in the chord. Therefore, it is "the bass number in relation to the tonic and the flat seven of the chord" that provides the

colours for the chord. Although not possessing AP, Lily's relative pitch (RP) skills are strongly enhanced by her intervallic thinking, which are in turn heavily aided by her synesthetic colours (see Figure 4.2).

Figure 4.2. A pathway representation of how synesthetic percepts can aide intervallic thinking, in turn enhancing relative pitch (RP) abilities. This pathway functions in the absence of absolute pitch (AP).

In the absence of AP, Lily's synesthetic percepts are focused on intervallic relationships over individual notes. The numerical relationship she is able to ascertain by employing her RP has thus outgrown the alphabetic relationship she was unable to employ without prior knowledge of the notes played. Her musical memorisation therefore centres on these intervallic layers of synesthetic colours, which scaffold her musical experiences, and are then aided by individual note colours that act as secondary markers to emphasise specific musical occurrences within a work.

4.1.1.3. Synaesthesia and overcoming difficulties.

Name	***Condition(s)***
Thomas	Synaesthesia

Not only do synesthetic percepts import mnemonic and structural cues valuable for music memorisation, they can also be highly influential in overcoming difficulties in recall, specifically in situations of stress, such as when performing. Memory lapses occur for all musicians and can be both debilitating and highly embarrassing. Thomas

described how synaesthesia enhances his ability to overcome memory lapses, by providing additional information with which to recall forgotten passages:

> THOMAS: If I have trouble remembering a passage, I can just say, "Well this passage is in red so I need to play notes that are in red. It moves from red to yellow, so I need to play notes that are in yellow." Then I can go, "Well these notes are yellow." So it's probably going to work if I play these notes. It works out to be about right.

Thomas' ingenious and somewhat improvisatory system does underscore an important synesthetic property: namely, that synesthetic percept is often recalled better than, or in place of, the initial stimuli (see Chapter 2.1.3.4.: 'Synaesthesia is memorable'). This is the case with Thomas, who remembers the upcoming associated colour of a piece in situations where he may not necessarily recall the exact notes. This understandably increases his confidence when performing, as well as gives him a greater structural understanding of the work as he is able to distinguish sectional changes based on their colour change: "this piece is in this colour; this section is in another colour. It's easier for me to remember what notes go in that part." As a structural aid, these colour percepts are effective. Their influence, however, is even more refined. As with other participants, Thomas noted that his synaesthesia increased the speed at which he was able to memorise music, while his synesthetic percepts enhanced his global understanding of the work:

> THOMAS: I can remember pieces faster. I feel that they give me a greater sense of the masculine and feminine in music, how people go, "There's two

different subjects." They come out as different colours, usually because they're in different keys. Then when I see the second subject, which is supposed to be in a different colour, then I can say, "Well it's now in this colour, so it changes its mood and changes that way."

Being able to structure the analysis of a piece around his synesthetic colours provides Thomas with an important interpretive framework. The visual and auditory aspects of his memory are also enriched by a secondary level of understanding, which in turn influences his expressive judgement of individual sections of the music.

4.1.1.4. Key points of synaesthesia and music memorisation.

All 18 of the synesthetes in this study (100%) reported a mnemonic advantage, directly linked to their synesthetic percepts. This advantage is both mnemonic and structural, and can aid in overcoming memory lapses, which in turn enhances confidence in performance situations. Synesthetic percepts were reported as leading to richer encoding and retrieval opportunities, as well as enhancing a synesthete's ability to structure and organise their musical memories.

4.1.2. Absolute Pitch

"If I read something, I can hear the actual thing in my head at the right pitch by reading it. So, it has a huge impact on how I remember things."

Max (AP)

Absolute pitch was overwhelmingly reported as being used as a mnemonic and structural aid to enhance music memorisation and is therefore employed in overcoming memory lapses during performances. Only one possessor reported a potentially negative effect of his AP on music recall with the cause of this deficiency in music memorisation remaining unclear. Absolute pitch was additionally reported as increasing the facility and speed of music memorisation. Finally, the pitch-labelling process was reported as being aided by the development of a 'sound bank' of accumulated memorised sounds.

4.1.2.1. Absolute pitch as a mnemonic aid.

Name	***Condition(s)***
Lucas	AP
Alexander	AP
Liam	AP

Absolute pitch was reported as being a mnemonic aid and fundamental component of music memorisation by possessors. Lucas, for example, noted: "When it comes to learning and memorisation…it serves as an important or vital memorisation or memory aid or tool." Lucas described hearing music in his mind in its "full form", with "every detail", and "exactly as I know it when I listen to it…I can remember it in virtually full detail, the pitch included." This illustration reinforces the role AP plays in his music memorisation strategy.

Like Lucas, Alexander similarly noted the importance of his AP in conveying a mnemonic advantage. Indeed, Alexander reported that the most important functional outcome of his AP is his heightened musical memory. This, he reported, has a direct effect on his practice regime, such that he devotes less time to physically working at

the piano, and more time listening to, and reading the score of the music. Thus, as a direct consequence of his AP he does not need to spend as much time committing the piece to muscle memory: “I've always regarded my perfect pitch as a sort of a catalyst and whenever I memorise music or when I actually perform in concerts, perfect pitch is like the flame behind the steam engine, I feel. It's always there and I sort of need it”. Alexander subsequently drew attention to his long-term musical memory, noting that he was able to recall major works he had publicly performed from the age of 9 onwards; he again justified the strength of this music memory as being due to the possession of AP. By his own admission however, his general memory is, in his estimation, only average.

The fundamental role of AP in music memorisation was similarly noted by Liam, who insisted he always remembers music in its original key, and finds it hard to comprehend how others could remember or imagine music without AP. The idea that one could ‘relatively’ remember a piece of music without it being in the correct key is a foreign concept for Liam. Indeed, he suggested that the pitch or tonality of music is an integral part of his memory of the piece. Liam estimated he possessed a very good musical memory, and speculated that this is related to his visual memory, even though his musical memory is stronger.

4.1.2.2. Structural cue.

Name	***Condition(s)***
Samuel	Synaesthesia and AP
Max	AP
Lucas	AP

Max draws on cues obtained by his AP to develop a structural outline of a piece, thus reinforcing his memory of the work. When questioned on how this occurred, Max pointed to his vivid musical imagery – his ability to internally hear what he is reading on a score – as the decisive influence on his musical memory:

> MAX: Well [AP] affects it in a big way. Because I know what the notes are and I can hear them (I know in my head) if I read something, I can hear the actual thing in my head at the right pitch by reading it. So, it has a huge impact on how I remember things.

Like Max, Samuel described having a robust ability to internally hear the score he was reading: "When I read it, I can hear it inside my head. It just kind of translates." This was exemplified in orchestral studies, where Samuel stated he can remember a whole symphony to the smallest detail after roughly three rehearsals. When queried as to the role his AP plays in his detailed musical memory he acknowledged this memory is always at the correct pitch, which enables him to form a better understanding of the tonal structure of the piece: "I think it's easier for me to understand the pitch and all those harmonic - the structure underneath it - and I think that might help with memorising it."

As seen in relation to synaesthesia, AP possessors similarly use note associations (in this case pitch labels) as structural markers when memorising music. Lucas, for example, acknowledged employing the opening pitch of orchestral excerpts in memorisation tests as their identifying feature. He admitted this creates an advantage as he is able to correctly recall them with ease: "that's the identifying feature and that's

something that almost no one else can do [laughs].” Pitch therefore becomes the most prominent feature of a musical excerpt and provides Lucas with structural markers to aide in the organisation of his musical memory.

4.1.2.3. Absolute pitch and overcoming difficulties.

Name	***Condition(s)***
Alexander	AP

Absolute pitch was reported as being an effective tool for overcoming memory lapses in performance situations. For example, Alexander described a concert he gave at the age of 10, as part of the Indonesian equivalent of a Guinness World Record attempt. He performed 50 pieces by memory over a 3-hour period, in front of a large audience: “I always call it the impetus of my music career: this particular concert I did when I was 10.” Alexander reported the positive impact possessing AP has on his ability to overcome memory lapses, such as one he experienced during this same concert:

> ALEXANDER: And in that concert, I always remember, in the twenty-fourth piece or something, in one of the pieces (it was "Liebestraum: Number 3" - a very famous piece by Liszt) for whatever reason, on page three, I stopped playing, I forgot. But I didn't really stop. I kept going and I was arranging. I was just playing random jazz and stuff for two seconds. But I think I just could hear the note of the next melody. It came back to it. I would say that perfect pitch has helped me, and not once - several times, especially in performances where I had a memory lapse…My personal opinion is that because of perfect pitch, I find it easier.

Alexander credited his AP with his ability to keep playing through a memory lapse: "I've never had that experience. I have had memory lapses when I stop but not really completely stop. I'm not stationary. I will keep playing…I think it's because of perfect pitch, in a way." As similarly noted by Thomas in relation to his synesthetic percepts (see Section 4.1.1.3.: 'Synaesthesia and overcoming difficulties'), Alexander's AP is influential in aiding recall, particularly in performance situations. The ability for AP to provide additional cues, in the form of precise auditory imagery ("I just could hear the note of the next melody"), is again evocative of the role of synesthetic percepts in enhancing the ability to overcome memory lapses. The additional mnemonic information provided by AP allows Alexander to locate his position within a piece, in situations where a temporary lapse in memory or concentration occurs.

4.1.2.3.1. Cooper: short-term memory deficiency and absolute pitch.

Name	***Condition(s)***
Cooper	AP

In the previous subsection, the ability for AP to aid in overcoming music recall difficulties was examined. In the introduction to this chapter, one participant – Cooper – reported a potentially negative influence of his AP on his musical memory. During the interview Cooper repeatedly discussed the difficulties he has with music memorisation, including rhythms. He stated this lacuna is isolated to music, and that other aspects of his memory are normal. Cooper reported that he experienced "some very embarrassing [laughs] memory situations in concerts", and admitted to having tried to actively use his AP to help in these situations by using notes as "markers", but to no avail. He also indicated that based on interactions with colleagues who do not have AP, he does believe his musical memory might be better if he did not have AP:

“I figure perhaps the way that I think of notes might affect the way that I remember them.” He was unsure, however, if this is correct, or if there is some other unknown factor that affects his memory.

When asked about the vividness of his musical imagery, Cooper bemoaned his short-term memory, and in particular his inability to ‘recall’ information. He explained that his musical imagery is “quite vague most of the time”, and posited that this is largely to do with his inability to recall what he had imagined, directly after the fact. Cooper acknowledged that he is able to internally hear several lines of music at once, but that it is the immediate recall of these lines that is problematic. Cooper faces the same problem when composing at the piano, feeling obliged to immediately notate any interesting ideas that come to mind, for fear of losing them.

Without being prompted, Cooper mentioned that he finds it difficult to “visualise colour very well”, while also drawing a comparison between his, and other people’s dream states: “like when people are dreaming at night and they can't tell the difference between the reality and the dream - I've never had that experience.” Cooper’s comments are important, and might suggest some sort of a deeper conceptualisation or visualisation deficiency. It might also be that his AP is not causal to his deficiencies in music memorisation as Cooper previously suggested, but that his difficulties are linked to deeper rooted short-term memory processing. Cooper’s case is nevertheless interesting, and appears to point to a clear distinction between the necessity for strong long-term memory in AP development, with a weaker emphasis on short-term memory.

4.1.2.4. Absolute pitch and increased speed of memorisation.

Name	*Condition(s)*
Alexander	AP
Oliver	QAP

A recurrent theme in interviews with AP possessors was the positive role of their AP in increasing the speed and efficiency of their music memorisation. As described by Alexander, "It's hard to explain it, but I really feel that perfect pitch really, really helps the speed of memorising something." A noteworthy example was provided by Oliver, who indicated that his auditory memory is the driving force behind the speed with which he is able to learn new works. When asked how his AP was beneficial in this context he replied:

> OLIVER: Every note has an identity…In the same way that a person has a name, the note has a sound. That sound is a memory in the same way that somebody's name is a memory...Over many years, I've had these multiple layers of memories of what those notes do and what these relationships are...It's as though you've had this long experience of this personality and you've seen the things this personality does in relation to other personalities. And that's part of your memory of what that note is.

To describe how Oliver distinguishes notes, he provided an example of the difference between an A and a G: "I hear the two notes in my head and I compare them. A is brighter; A is more insistent. G has a certain assertiveness but not the assertiveness of A." Due to his AP, Oliver thus associates an individual 'personality' to each note, which enables him to gain a greater depth of understanding of the work he is learning.

In his opinion this considerably enhances the speed with which he is able to commit a work to memory.

4.1.2.5. 'Sound bank' and absolute pitch development.

Name	*Condition(s)*
Noah	AP
Lucas	AP
Oliver	QAP

When questioned on their pitch-labelling process, AP possessors frequently indicated making reference to the memory of a discrete musical event, such as a familiar piece or song. These embedded pitch-memories enabled subsequent heard notes to be 'error-checked' against the internal memorised sound. One highly specific and detailed example of this system of sound memorisation was described as the development of a 'sound bank'. In the following section, three cases that emphasise the development of a 'sound bank' are presented. All three participants – Noah, Lucas, and Oliver - did not commence formal musical training until a substantially later period than their peers (see Appendix A). Furthermore, all described heightened pitch sensitivity before this training, while the ability to label notes was considerably aided by the development of individual 'sound banks' of stored memories of specific pitches, usually linked to opening or notable notes of familiar songs or pieces.

4.1.2.5.1. Noah.

When describing how he is able to label notes, Noah made reference to a "bank" of sounds: a classification system usually linked to familiar songs of emotional significance for him, such as the first bands he felt a musical connection with (see Table 4.1).

Table 4.1
Noah's 'sound bank', with songs or music situations he links to specific notes

NOTE	MUSICAL EXCERPT IN 'SOUND BANK'
C	"Tomorrow Never Knows" by The Beatles.
C#	"Echoes" by Pink Floyd - the first chord is C sharp, the root.
D	"Rumble" by Link Ray.
Eb	"Voodoo Child" by Jimi Hendrix.
E	As a guitarist, I think I could easily recall the sound of an open E string and that was 'E' for me.
F	The tuning note for horn.
F#	"Foxy Lady" by Jimi Hendrix.
G	"Paperback Writer" or "Rain" by the Beatles.
Ab	The first note of Jimi Hendrix's "Are you Experienced?"
A	The first note of the Beatles "I Feel Fine" - the feedback note.
Bb	The tune up note in Wind Band.
B	Like a B7 chord because for some reason it just sticks in my mind on guitar.

Noah began depositing musical excerpts into his 'sound bank' between the ages of 9-12; to be able to label notes he was hearing, he would refer to these excepts:

> NOAH: In my brain, I've got a bank that has the sounds of all the different pitches - what they sound like - and I can just mix and match and link it up with what I'm hearing. That's the bit that I don't understand or I didn't understand why it's so special. I just thought that everyone could remember what the pitch sounded like and just line it up.

Indeed, Noah stated his earliest memories of AP were from the age of 5-6, when he was able to understand that songs were not being performed in the "right" key: "I think I can remember probably being five or six. If there was a song I knew and then I think I heard a cover version or something and it was in a different key and I knew it, I thought, "Wait, that's not right!"" Noah's 'sound bank' was therefore what enabled

him to learn how to *label* notes, even though his ability to *distinguish* and categorise specific tonal qualities was already functioning.

These earlier memories preceded the commencement of his formal training at the age of 10, while his investment in his 'sound bank' occurred at roughly the same time as his initial training. It can therefore be speculated that the development of his 'sound bank' acted as a classification aid to his budding pitch-labelling ability. This also ties into comments he made concerning how he perceived individual notes as possessing specific "personalities", which he believes is linked to how they were taught.

As an adolescent, Noah would label notes by referring to his internal 'sound bank', and linking the pitch label of the note to the song or sound he was internally hearing. Nowadays, however, the pitch labelling process is automatic, and he no longer needs to refer to this bank.

It is also worth noting that this is not the only tool Noah employs in the note labelling process, as he also mentioned visualising notes on a guitar fretboard (see Chapter 7.2.2.2.2.: 'Visual concurrent', for a further discussion of visual imagery during the AP labelling process). Both Noah's 'sound bank' (i.e., internal auditory memory), and visualised fretboard (i.e., internal visual memory) are used as a note labelling strategy, even though he remained unable to describe when and why one system would take precedence over the other.

4.1.2.5.2. Lucas.

Like Noah, Lucas described how his sensitivity to pitch has always existed, but that his AP ability developed by systematically memorising pitch labels:

> LUCAS: For as long as I can remember, I've always been sensitive to pitch and I had an acute awareness of where something was - where the chord doesn't quite mesh properly or something just doesn't quite sit right. You can hear the disturbances. I always had that ability, but the arbitrary concept of assigning letters to individual pitches is something that I just had to learn by repetition …and I did that in my later years of high school…I think I developed perfect pitch just through what some might call "pitch memory".

When asked how he was able to label pitches, Lucas acknowledged referring to a visual image of a keyboard:

> LUCAS: I visualise a keyboard, actually. I'm surprised that I didn't mention that sooner. Before I was able to associate letter names with the pitches…I found it helpful to memorise - take a photograph of an octave on the piano and just keep it in my mind. That would usually be my first port of call.

Lucas described this image as instantaneous, but only for music at A=440, as it does not appear when he performs at baroque pitch. This visual image of a keyboard was not the only tool Lucas employed in the development of his pitch-labelling abilities. In a description that parallels comments make previously by Noah, Lucas described using a ‘sound bank’ to enable him to learn pitch labels:

> LUCAS: [Pauses] [Laughs] I just had an epiphany. I actually remember how I learned pitches, or letter names. For songs that I listened to throughout my teens I would remember the first note of a song or a particular passage in the middle of it. If someone asked me to sing an A, often I would think of that one particular song to which I had assigned that pitch or taken the pitch from. So, if someone asks me for an A: "Oh, an A. That's the same pitch as that particular segment of a song that I know" ("On my Own" by an American band called “Saosin”: The start of the chorus or the pre-chorus comes in on a high tenor A so it really sticks out). So often I will immediately - when I'm not visualising a mental image of a keyboard or a piano - use a song. That's another strategy I use, or a backup. So, it's not that intuitive identification of notes. At least, not until more recently like the last one or two years. As I've had more practice with it and got more familiar with my template of notes of the 12-tone scale, then it's become easier. I don't need to rely on songs so often. I can just produce it at will. I don't have to think much about it.

These two descriptions from Noah and Lucas are almost interchangeable: both include reference to pitch sensitivity well before the onset of formal musical training. Both refer to visual imagery of notes on an instrument, and both include additions to an internal bank of sounds during adolescence that was often characterised by the opening or meaningful passage of a favourite song or piece. For both participants, these ‘sound bank’ deposits enabled pitch sensitivity and differentiation to develop into pitch labelling.

Whereas Noah was unable to clarify when and why he utilised his visualised guitar rather than his ‘sound bank’, Lucas drew an insightful distinction between the two. For him, this distinction lies in whether he is being tasked with either labelling or producing a note. In the former, the visualised octave of the keyboard serves as a mnemonic aid to his pitch labelling, while in the latter he will use his memorised song extracts as a template over which he is able to produce (in his case sing) the required note. Both strategies are therefore used in functionally different ways.

4.1.2.5.3. Oliver.

The concept of a ‘sound bank’ was given an architectural twist by Oliver, who referred to a similar classification system as both Noah and Lucas when discussing the role of memory on the development of his AP ability. When designating where he situates individual pitches, Oliver stated: “If I imagine the spaces in my brain as three dimensional, they do seem to sit in different places.” He elaborated on this, stating these places are:

> OLIVER: [Pauses] Tied to time and space. It's as though I've retained a memory of everything I've ever heard and that whatever I hear then gets mapped against that memory. Sometimes the memory will be of a very specific performance on a specific instrument in a specific space. And other times it will be a more generic memory of, "Oh that's what an A sounds like because that's always what A sounds like." It's almost that there's a cathedral and things are sitting in different places. Yes, a time and space memory, I'd have to describe it as.

Labelling notes is therefore an exercise in filtering the heard sound through an internal template of sounds, and relating it to all the other sounds that have been heard previously. Oliver described this as being a "very quick comparison with everything I've ever heard before. It's as though you're playing it against a bank of memories of sounds." When asked to describe how the "bank" originated, he replied:

> OLIVER: I suspect from listening. Because I was listening to music on mum's knee that was on the radio; because I was listening to broadcasts on the school radio in Prep and Grade 1; because I was listening to music in church, I was developing this storehouse of songs. After a while, the information that you'd learned from one song transferred into less familiar repertoire because you'd make comparisons all the time. You'd hear a new song and you kind of hear the bits in it that were like old songs that you knew. You'd hear the things that were unique to that song. So maybe there's some other lateral thinking involved there as well.

It is self-evident that all hearing children listen; they are exposed to music in their everyday lives in much the same way as Oliver. The vast majority of children, however, do not develop AP. This example demonstrates Oliver's discernment and sensitivity to pitch, which enables him to perceive associations between banks of sound memories he has stored since childhood. The example also highlights the temporal development of his AP, particularly in terms of the timing of his earliest formal training. In a strikingly similar way to both Noah and Lucas, Oliver depicted his ability to differentiate tones as occurring for as long as he could remember, and well before the onset of any formal musical training:

> OLIVER: The memory of actual sounds and retaining them must have always been there somehow. I was taken to hear the Melbourne Symphony at the age of 10 by one of the neighbours. My strongest memory of that concert is still of the harp tuning everybody to play the A. I can still hear the A on the harp and I can still hear the violins playing exactly that sound. The symphony was a wonderful, voluptuous effect. I don't remember the works that were performed but I still remember the sound of the tuning as the most fascinating thing I've ever heard!

Not only did this concert experience occur shortly before Oliver began musical training at the age of 11, but his strong recollection of that tuning A is one further example of an internal 'sound bank' deposition. The effect produced by that sound was considerable enough to enable it to be unceasingly recognisable to Oliver; a distinct sound memory, internally stored, which is still accessible to him today.

4.1.2.6. Key points of absolute pitch and music memorisation.

Of the 28 AP possessors in this study, 27 (96.4%) reported a mnemonic and structural advantage of their AP on their music memorisation. Absolute pitch was also noted as providing assistance in overcoming music recall difficulties, although one case of the potential hindrance of AP in music memorisation was reported. Examination of this specific case, however, revealed that AP is unlikely to be causal in the participant's music memorisation deficiencies. Absolute pitch was also reported as playing a positive role in increasing the speed and efficiency of music memorisation, because it leads to richer encoding and retrieval opportunities. Furthermore, AP possessors

described the development of a ‘sound bank’ of memorised musical excerpts, which assisted the learning of pitch labels. This strategy was typically accompanied by a second strategy that employed the visual image of an instrument to facilitate pitch labelling and enhance the organisation of a pitch classification system.

4.1.3. Summary of Memory

To summarise, the cases described above reveal self-reported enhanced musical memory, directly linked by participants to their conditions. Synaesthesia and AP were reported to overwhelmingly aid in music memorisation tasks, with mnemonic benefits reported in 97.1% of cases. Furthermore, this advantage was reported as being ‘strongly positive’ in 80% of cases. Synesthetic experiences and AP associations provide richer worlds of experience, and thus the ability to better structure and organise memory. The additional cues provided by these conditions offer possessors retrieval cues for musical material when needed. Indeed, participants frequently reported their condition aided in the recall of musical material, specifically in situations of stress or anxiety, such as when performing. In these aspects, reports from AP possessors mirrored those conveyed by synesthetes in this study.

Synesthetes and AP possessors both noted that their conditions increased the accuracy and speed of music memorisation, although this effect was more pronounced in reports from AP possessors. Furthermore, AP possessors frequently described retrieving embedded pitch-memories of discrete musical events as part of a pitch-labelling strategy. The development of a ‘sound bank’ was examined as a comprehensive example of a system of sound memorisation that assisted in the learning of pitch labels. Within the discussion on the development of a ‘sound bank’,

the intersection of musical memory and various forms of imagery was described. This theme will now be explored in more detail in the following chapter section, which examines the influence of synaesthesia and AP on imagery.

4.2. Imagery

"For me, that's the powerful force: that I hear the sound in my head and whatever format I need to deliver it in, it's there. I'm not just a pianist, I'm not just an organist or a singer: I'm a musician. I can choose to work in any medium because when I hear a sound in my head, I can write it."

Oliver (QAP)

Imagery was an unexpectedly prevalent topic of discussion during the interview process, and one that was often elaborated on by the participants themselves. Due to the frequency with which it was discussed, and based on a review of the literature, the section that follows assesses the role of synaesthesia and absolute pitch (AP) on unimodal and multimodal mental imagery.

Even though most humans are not necessarily conscious of it, mental imagery is an integral component of everyday perceptual processing. Mental imagery can be defined as perceptual processing that is not triggered by corresponding sensory stimulation in a given sense modality, where the representation of sensory information is formed without direct external stimulus (Nanay, 2017; Pearson, Naselaris, Holmes, & Kosslyn, 2015).

Within the framework of mental imagery, two subgroups can be delineated: *unimodal* and *multimodal* mental imagery. Unimodal mental imagery refers to perceptual processing in a particular sense modality, without corresponding sensory stimulation of that same sense modality. Both visual and auditory imagery (VI and AI respectively) fall into this category, as they refer to conscious or unconscious visual or aural activation, lacking a perceptual trigger (direct visual or auditory perceptual input). Multimodal mental imagery (MMI), on the other hand, refers to mental imagery that, while not triggered by direct stimulation of the sense modality in question, is triggered by sensory stimulation of a different sense modality (Nanay, 2017). The majority of our encounters with everyday objects and events are multisensory, and it therefore follows that MMI is equally as common.

In the following analyses of the results, these two forms of imagery are examined separately. First, the influence of synaesthesia and AP on the enhancement of one form of unimodal imagery – auditory imagery (AI) - is investigated. The specific influence of AP on AI, and the resulting musical benefits associated with an enhanced degree of AI are then examined. Second, in the context of multimodal mental imagery, the functional relationship between synaesthesia and AI is explored. This includes an investigation of the capacity for AI to induce synesthetic percepts. Furthermore, a case study of AI potentially induced by synaesthesia is analysed. To conclude, this section presents unexpected data from five case studies, demonstrating examples of complex visual imagery (CVI) induced by musical stimuli.

4.2.1. Unimodal Mental Imagery

"[Auditory imagery is] probably the main factor in [pauses] or the main part of what I do. Ninety per cent of working stuff out is being able to do stuff in my head musically."

Noah (AP)

Unimodal mental imagery can be described as perceptual processing that occurs without corresponding sensory stimulation. Auditory imagery (AI) is one example of either conscious or unconscious processing, lacking direct perceptual input (Nanay, 2017). While research into the reported strength of AI by synesthetes and AP possessors is lacking, higher self-reported levels of visual imagery (VI) in synaesthesia have been previously reported (Barnett et al., 2008; Price, 2009). To examine this question from an auditory perspective, the self-reported intensity of AI from participants in this study was reviewed. Furthermore, an analysis of the positive influence of AP on AI, and the resulting benefits, was undertaken. These analyses conclude with an assessment of the positive effect of AI, as highlighted through a rare case of its loss.

4.2.1.1. Auditory imagery.

The four self-reported levels of auditory imagery (AI) from both synesthetes and AP possessing participants in this study are outlined in Table 4.2. Labelling of both 'extreme' and 'strong' levels of vividness occurred when participants indicated that their AI was "as strong" as hearing music externally (live or recording): the differentiating characteristic between the two levels was that they were labelled as

'extreme' if they indicated their AI could "block out" external sounds, whereas those labelled as 'strong' could not. A 'high' level of AI indicated being able to hear music vividly in the 'mind's ear', although this level of audiation is less clear than hearing external music. A 'low' level of AI indicated the inability to clearly hear music internally. A fifth level – 'extremely low' - was also suggested, indicating a lack of AI, however none of the participants in this study stated this was the case.

Table 4.2
Overall responses to the question: "How vivid is your auditory imagery?"

Vividness of Auditory Imagery	Number of Participants	Percentage	Cumulative Percentage
Extreme (blocks out external)	10	28.6	28.6
Strong (like external)	15	42.9	71.4
High	9	25.7	97.1
Low	1	2.9	100.0
Total	35	100.0	

As can be seen in Table 4.2, only one participant – Cooper - described the vividness of his mental imagery as 'low'. Cooper previously depicted the potentially negative effect of AP on his musical memory (see Section 4.1.2.3.1.: 'Cooper: Short-term memory deficiency and AP'), and furthermore acknowledged never having lucid dreams, which is a noteworthy admission, as lucid dreaming is widely considered to be a form of mental imagery (Nanay, 2017). There is therefore a strong case to suggest an association between Cooper's low levels of reported AI, lack of lucid dreaming, and difficulties in short term memory retention.

Both synesthetes and AP possessors reported high levels of AI. A comparison of the levels of AI reported by synesthetes and AP possessors uncovered no noteworthy differences between groups. Of particular interest in Table 4.2 is the percentage of participants who described the vividness of their AI as 'extreme', i.e.: as able to block

out external sounds. Indeed, 28.6% of all participants (n=10) indicated experiencing extreme AI. A table of representative quotes from these 10 participants is provided in Appendix H in order to illustrate this point. Overall, when asked to compare their auditory imagery (AI) with their visual imagery (VI), all participants asserted their AI was markedly stronger. Whether this is due to their musical training in general, or their condition(s) more specifically, remains unclear.

The analyses of reported levels of AI also sought to distinguish whether there were any factors that differentiated imagery from live performance in participants who indicated high levels of AI. In the case of Oliver, the differentiation was not due to the vividness of the perceptual phenomenon, but rather to its ability to 'surprise': "The only difference is that in the live situation, if someone else is playing, there can still be some surprises. An instrument could suddenly have a resonance that you didn't expect or that somebody might think to turn a phrase in a way that you didn't imagine. Other than that, the mental image of the music in my head is as strong as an actual performance." In a similar manner, Joshua noted that what distinguished his AI from external hearing is that his internal perception of time differed from the external one, and he could therefore speed up or slow down the imagery at will. This sense of control over the imagery process was also highlighted by Liam, who stated that not only is his AI strong and loud, but that he can "turn it up" at will, enabling him to block out exterior sounds.

A heightened level of AI was often perceived as "normal", with participants repeatedly appearing surprised to learn their AI may be stronger than average. This heightened AI was frequently reported as being present since early childhood, and

indeed before commencing formal musical training. William, for example, recalled internally hearing music he had heard on the TV shows ‘Rage’ and ‘Video Hits’, which he used to love watching. He also recalled involuntarily hearing individual notes in his mind, specifically G, A flat, and A, although he did not associate labels with what he was internally hearing until he began piano lessons and was taught what these internally heard notes were called. William believes that having a strong long-term memory contributed heavily to this ability, which he saw as the foundation of his AP.

While both synesthetes and AP possessors reported that their conditions enriched their AI, AP possessors described advantages in specific musical contexts due to their AP-enhanced AI. Such reports are outlined in the following section.

4.2.1.2. Absolute pitch, auditory imagery, and associated benefits.

Name	***Condition(s)***
Benjamin	Synaesthesia and AP
Joshua	AP
Alexander	AP
Noah	AP

Auditory imagery (AI) is a fundamental element in the musical lives of musicians. Joshua, for example, stated that the positive influence of AP on his AI or “inner ear” is one of the most valuable outcomes of his AP. As a Lecturer in Composition, this is particularly salient in regard to the positive impact AI exerts on his ability to compose. Indeed, Joshua considered his heightened AI to be so important, that he rated it as the most valuable and enjoyable aspect of possessing AP: “I think it's probably the ability to internalise - the ability for musical imagery is really what I find

it most valuable for. [Pauses] Yeah, I think that's probably what's most enjoyable about it."

Like Joshua, Benjamin considered his AP to appreciably aid his AI, and noted he is never 'wrong' with his internalisation of the pitch or harmonisation of parts. Benjamin can internally listen to music with all the inflections and details of a real rendition of the piece, and is able to block out external noises, by losing himself in his internal performance. He described this ability in relation to his habit of walking around the school periphery as a child, alone, and composing in his head, where he could "block out the sounds of the children [pauses] with the music."

The positive impact of AP on AI, and the benefits this incurs, is similarly illustrated in reports from Alexander and Noah. Alexander declared that he hears a constant soundtrack playing in his mind: a phenomenon he had never discussed with anyone before. His AI is a polyphonic imagery, where he is able to internally hear all of the harmonic components of a symphony or concerto. While internal, he does sometimes sing or hum along, when alone. This internal soundtrack is constant, and accompanies his everyday activities. In a similar manner, Noah described his AI as "probably the main factor in [pauses] or the main part of what I do. Ninety per cent of working stuff out is being able to do stuff in my head musically." Vivid AI is therefore central to a substantial amount of Noah's daily music making and consumption of music. The impact of AP on the veracity of AI is therefore a key element of the musical lives of these possessors.

4.2.1.2.1. Oliver: positive effect of auditory imagery highlighted through a rare case of its loss.

Name	***Condition(s)***
Oliver	QAP

The positive effect of AP on strengthening AI was similarly noted by Oliver. When asked which of his musical abilities were enhanced by his AP, Oliver signalled out his AI, stating, "imagining the sound that I want to create." For Oliver, imagery is vital to his music making, for several interconnected reasons:

> OLIVER: That's what makes me a quick study. That's what makes me a sensitive accompanist. It's what makes me able to arrange or compose because I can imagine the sound and then I can put it on the page or I can play it at the instrument. Those two processes are actually the same thing for me. Whether it hits the air first or whether it hits the page first; it's not really any different other than you can go back with the rubber and change your mind later, whereas once it's committed to the air, everyone's witnessed and heard it and it's indelibly etched in their memory. For me, that's the powerful force: that I hear the sound in my head and whatever format I need to deliver it in, it's there. I'm not just a pianist, I'm not just an organist or a singer: I'm a musician. I can choose to work in any medium because when I hear a sound in my head, I can write it.

The above quote highlights the value of AI in terms of Oliver's musical development, and its centrality to his ability to adapt to different situations, to his creative output,

and to his skill as a performer. His vivid AI, fuelled by his AP, therefore shapes his musicality on a cognitive, affective, and behavioural level.

Oliver, however, tragically yet temporarily lost both his AP and - consequently - his AI abilities following a serious road accident approximately 10 years before being interviewed. By highlighting the sudden deficit of his AI, this incident provides a rare insight into its importance:

> OLIVER: While I was still in the wheelchair, I did a concert with a singer that I'd worked with quite a lot. Normally my process at the piano of accompanying would be that I'm looking at the page and I'm imagining the sound in my head. My fingers play the sound that I've just imagined and it's in that order. So, I'm reading a bar ahead. The sound in my head is almost a bar ahead and then my fingers play it. At some stage in that concert, that split, and I had no way of knowing where I was supposed to be. I kept having to ask my page turner to point to where I was supposed to be on the score. The concert didn't fall apart but it came very close to it, simply because I couldn't maintain the thread of the sound in my head: the image of what it was supposed to be.

When broken down into stages, this example demonstrates that Oliver's ability to read the music on the page remained intact following his accident, as did his ability to physically play the notes; it was his ability to internally hear the music he was about to play that was impaired. Thus, Oliver's AI was malfunctioning.

Not only did this mar his performance, to the extent that he came close to having to stop playing altogether, but it also negatively impacted his confidence in his performance abilities: “The link with the sound had gone or was breaking down like a radio that keeps going in and out of playing. I was sort of, "But where's the sound? What am I supposed to be doing?" It was an alarming moment.” Through practice and careful training, Oliver has been able to recapture elements of his AP and AI abilities, yet the effect of this accident on both his aural acuity and confidence continues to be felt today. Indeed, while he asserted that his AP ability was robust before the accident, he now performs within the QAP range.

4.2.1.3. Key points of unimodal mental imagery.

Synaesthesia and absolute pitch (AP) were reported as frequently enhancing auditory imagery (AI). This enhancement, particularly when triggered by AP, was reported as having perceivable benefits for participants, including positive effects on musicianship skills, such as composition and sight-reading. The above examples outline the benefits of synaesthesia and AP on AI: a form of *unimodal* mental imagery. In the following section, the interaction of synaesthesia and AI within the context of *multimodal* mental imagery are examined.

4.2.2. Multimodal Mental Imagery: Synaesthesia and Complex Visual Imagery

> “It was really quite hard to focus on practising when every time I was playing in a certain key, I'd see this colour. Sometimes I'd see images of animals or flowers or something. I don't know why. To this day, I don't know why.”
>
> *Ethan (synaesthesia)*

Multimodal mental imagery can take on a number of forms, but one specific form of perceptual phenomena that falls into this category, and which is of particular interest to this study, is synaesthesia. Focusing on synaesthesia as an idiosyncratic form of MMI increases understanding of the synesthetic phenomenon. This is why the following section focuses on an exceptional and distinct example of synaesthesia as MMI: that of complex visual imagery (CVI). Cases of involuntary CVI in response to auditory (musical) stimuli reported by certain participants in this study are examined. These cases are particularly salient in light of the diagnostic criteria of synaesthesia, according to which synesthetic percepts are stated as being generic in nature and excluding complex scenes. The presence of reports of CVI in this study is therefore noteworthy. This section is focused on cases of CVI reported by synesthetes, however one case of CVI reported by an AP possessor will also be considered.

As noted in the introduction to this section on imagery, multimodal mental imagery (MMI) is a form of perceptual processing that is not triggered by sensory stimulation in the *same* sense modality. It does, however, involve sensory stimulation from a *different* sense modality. The question of MMI is addressed in the following two subsections: first, with the exploration of the functional relationship between AI and synaesthesia, and second, with case study analyses of reported cases of music-induced complex visual imagery (CVI).

The relationship between synaesthesia and AI is examined bidirectionally. First, the potential for AI to induce synesthetic percepts, thus bypassing perceptual triggers altogether, is examined. Second, the potential for synaesthesia to act as a trigger for

AI is investigated by examining a rare case of potentially bidirectional sound ←→ colour synaesthesia. The second section of this exploration of MMI reports on unexpected data collected during this study concerning cases of music-induced involuntary complex visual imagery (CVI). Five case study analyses of CVI (four synesthetes and one AP possessor) are presented, including reports of familiar and unfamiliar scenes.

4.2.2.1. Auditory imagery inducing synaesthesia.

Name	***Condition(s)***
Xavier	Synaesthesia and AP
Olivia	Synaesthesia and QAP
Charlotte	Synaesthesia

Cases of AI-induced synesthetic percepts were reported by both Olivia and Xavier, who described their AI as consisting of musical imagery in the correct key. These subsequently induced forms of synesthetic colours are typically associated with the corresponding pitch or tonality of their AP. While Olivia asserted the AI-induced synesthetic colours would be identical to those induced by a genuine musical experience, Xavier noted that for him the shades of AI-induced synesthetic colours are faded and lighter than sensory-induced synesthetic percepts.

In a similar fashion, Charlotte indicated that AI induces her corresponding synesthetic colour percepts, yet acknowledged that since she does not have AP, she finds herself in situations where her AI-induced colour percepts are "wrong". If she subsequently plays the music she was internally hearing and finds her AI to have been in the wrong tonality, her synesthetic colour percepts immediately change to reflect the colours associated with the corrected tonality.

Voluntary AI can therefore trigger corresponding MMI – in this case synaesthesia - thus bypassing perceptual triggers altogether. The functional differences between multimodal mental imagery, sensory-induced synaesthesia, and imagery-induced synaesthesia, are outlined in Figure 4.3.

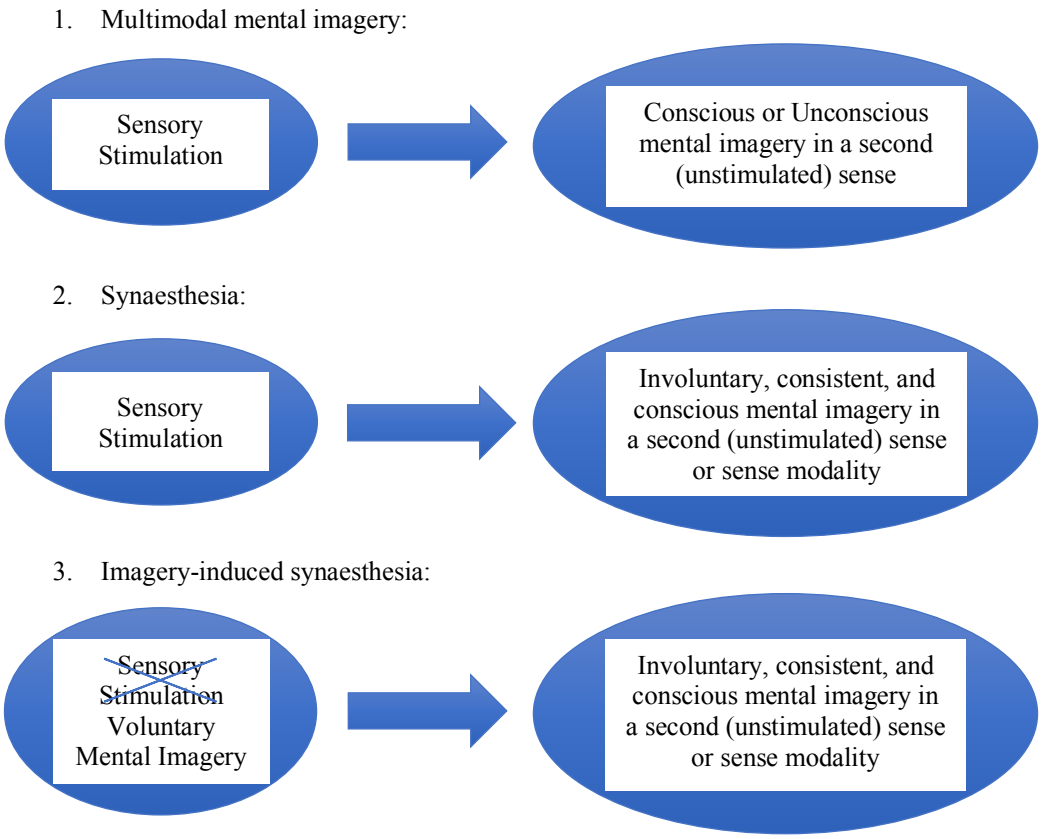

Figure 4.3. A representation of the functional difference between multimodal mental imagery (MMI), synaesthesia (as a specific form of MMI), and imagery-induced synaesthesia. In imagery-induced synaesthesia (pathway number 3), synaesthesia is induced without direct sensory stimulation.

4.2.2.1.1. Synaesthesia inducing auditory imagery.

Name	***Condition(s)***
Ethan	Synaesthesia

To examine the possibility that synaesthesia could induce involuntary AI, the case of Ethan, who potentially exhibits a rare case of bidirectional synaesthesia, was

examined. For Ethan, not only does music induce colours, but seeing a vibrant colour on a large surface directly after practicing will, conversely, induce music:

> ETHAN: I'll play a chord or I'll hear a chord or a melodic sequence in my head. After a while, it will stop. If I've been playing in D major and I see the bright colour yellow, I will then have a piece – completely away from what I've been playing, though – playing in my head. I will probably have never played it before, or maybe played it. I don't know. I'll just hear this piece and it will be interesting and then it will go away in about ten minutes if I stop looking at the colour.

While the above example could indeed be considered a form of bidirectionality of Ethan's synesthetic percepts, there are elements that link his perceptual experience more closely to imagery than to synaesthesia. First, the gold standard of consistency is conspicuously absent in the bidirectional workings of this potential form of synaesthesia; for example, while music in D major will automatically induce bright yellow percepts for Ethan, the opposite only holds true after practicing or performing in the associated key directly beforehand. Thus, what could be termed 'bidirectional' is potentially a flow-on effect, where the musical percepts will 'bleed' into his experience of the colour Ethan is physically seeing, due to his preceding associative experience. Since viewing the colour yellow does not typically induce music percepts for him without prior immediate exposure, this music is more akin to involuntary AI than to a genuine synesthetic experience. Second, the music Ethan experiences is not stable in nature, for while the colour yellow will always induce music in the key of D major, the music itself varies, and includes both known and unknown works. Last,

Ethan suggested these musical percepts last for “about ten minutes” after he stops viewing the displayed colour in question. This clearly violates the concept of a direct perceptual inducer, and contrasts with what Ethan reported for the initial direction of this form of synaesthesia, whereby the colour percepts he sees when listening to music cease once the musical stimuli has stopped.

As the consistency, stability, and duration of the AI in question all violate contemporary understanding of synaesthesia, it is possible this colour→music form of perceptual experience is an involuntary and vivid AI experience. The reliance of this specific case of AI on an involuntary and vivid prior genuine synesthetic experience does, however, leave this question open, as his induced musical percepts are evidently profoundly contingent on his synaesthesia.

Regardless of whether this perceptual experience of music is synaesthesia or imagery, Ethan described it as “incredibly vivid”, to the extent that he “can’t really focus on anything else.” Indeed, he classified the experience as being more vivid than listening to real, externally generated music: “…if something is playing on the radio, you can still hear other people. It's more that I can't hear anything but it.” Thus, like other participants, Ethan described this internal musical experience as qualitatively different and heightened.

4.2.2.1.2. Key points of the function of auditory imagery in synaesthesia.

Heightened AI was reported as potentially triggering involuntary synaesthesia, facilitated by synesthetic or AP associations. As the case of Charlotte indicates, AP is not a necessary condition for this to occur. Thus, not all MMI requires sensory

stimulation; rather, synaesthesia is a form of perceptual processing that can be triggered by AI. Synesthetic percepts were also reported as inducing AI in a rare case of potentially bidirectional sound←→ colour synaesthesia. As the perceptual experiences of music reported by Ethan are contingent on his genuine sound→colour synaesthesia, yet fail to meet the diagnostic criteria of synaesthesia, it remains unclear whether his unique case is best classified as synaesthesia or imagery. Regardless of its exact definition, this experience is highly vivid.

The above examples highlight the importance of AI within synesthetic processing, as well as underscore the potential for synaesthesia to induce AI. The following section examines cases of complex visual imagery (CVI) uncovered during this study.

4.2.2.2. Complex visual imagery.

Visual imagery (such as coloured percepts) induced by an auditory trigger (such as music) is one of the most prevalent documented forms of synesthetic multimodal mental imagery (MMI) (Niccolai et al., 2012). In these cases, the visual imagery (VI) induced is generic in nature, consisting of colours and simple geometric shapes. The second diagnostic criteria of synaesthesia, "Synesthetic percepts are consistent and generic", is thus of particular interest to this section on MMI (see Chapter 2.1.3.: 'Diagnosing idiopathic synaesthesia'). Indeed, the second concept outlined in this criterion is that synesthetic percepts are 'generic', in that they correspond to basic perceptual qualities. These 'form constants' (lines, spirals, blocks, grills, or geometric forms) were initially identified in the 1920s by the German psychologist Heinrich Klüver, and are not elaborate or pictorial (Cytowic, 1989). This is an integral aspect

of the synesthetic phenomenon, which sets it apart from hallucinations (Hochel & Milán, 2008).

Genuine synesthetic percepts are widely accepted as being generic in nature and lacking complex or pictorial properties. The limited nature of synesthetic percepts is thus broadly unchallenged in contemporary research. Within this study, however, five participants reported experiencing complex visual imagery (CVI) in response to musical stimuli. The group of five participants was comprised of four synesthetes (equating to 22.2% of the total synesthete group), and – remarkably - one non-synesthete AP possessor. To be able to ascertain whether complex cases of VI can be viewed as valid forms of synesthetic processing, they must meet the remaining diagnostic criteria of synaesthesia. Of these criteria, the two most fundamental aspects are their involuntary nature, and consistency.

The first of these diagnostic criteria refers to the involuntary and automatic nature of synesthetic percepts. This subsection examines cases of involuntary CVI: cases where synesthetes (and one AP possessor) indicated that their percepts were complex or pictorial in nature, yet simultaneously and automatically induced by specific musical excerpts or pieces. These images are reported in all cases as being involuntary, and unable to be suppressed. As such, these complex images fulfil the first diagnostic criteria. The question of their consistency is addressed within the following case studies.

The complex images reported slot neatly into two broad categories: images of unfamiliar scenes or objects, and images of familiar places. Cases falling into these two categories follow within the descriptions provided below.

4.2.2.2.1. Unfamiliar scenes.

Name	***Condition(s)***
Matilda	Synaesthesia and AP
Ethan	Synaesthesia
Charlotte	Synaesthesia

Of the five participants in this study who reported CVI, three indicated that their imagery was of places, landmarks, or objects that were *unfamiliar* to them. The scenes described fitted broadly into the categories of nature (sun, trees, woods, grass, leaves, flowers), or locations (roads, intersections, crossroads, buildings, towers).

4.2.2.2.1.1. Case study 1: Ethan.

Ethan possesses a rare form of projected, potentially bidirectional sound←→colour synaesthesia. He reported his percepts are often overwhelming, and this difficulty is equally perceivable in discussion of his CVI:

> ETHAN: I'd been experiencing what felt like a blur of senses in a way that I couldn't really focus on one or the other. I couldn't focus on one sense. I couldn't focus on just listening to music without seeing these colours and it got to the point where I just got really frustrated with it. It was really quite hard to focus on practising when every time I was playing in a certain key, I'd see this colour. Sometimes I'd see images of animals or flowers or something. I don't know why. To this day, I don't know why.

This description of animals and flowers was the first indication Ethan provided of visual imagery that was of a complexity beyond that of mere geometric shapes and forms. Ethan elaborated on the relationship between the colours and images he sees associated with specific tonalities. For him, D major is yellow, and he described one particular Mozart *Sonata* he was playing for which he would "frustratingly" automatically see flowers; "I keep seeing flowers and I don't want to see flowers…It starts off with yellow, then it goes from yellow to - I don't know what the flower is called - but a yellow centre and white petals around it". This image is highly vivid, and is of the same colour as the synesthetic colour associated with the music.

The nature scene Ethan described is present every time he plays this particular piece, and is not only "frustrating", but also inhibiting, as the instantaneous key changes of the *Sonata* are accompanied by equally instantaneous 'scene' changes. Ethan reported being influenced by his synesthetic percepts in his interpretative decisions, and thus this lack of gradual development increases his difficulty in transitioning between sections: "I'll find it really hard to get a gradual feeling throughout the entire piece." In an attempt to counteract this effect Ethan made the deliberate choice to write down the colours and images he sees directly onto his scores. As notated recollections of his imagery, these representations are used to enhance his ability to play "in that mood". Ethan has found this method to be effective in allowing him to smoothly and optimally interpret the music he is playing, and thus "all my scores are literally just covered in pencil markings of different colours, different notes and different images."

Ethan was not aware of any connection between the music and specific imagery he sees. There was, however, one exception:

> ETHAN: This Debussy piece that I'm playing at the moment, whilst there's no colour that comes with it, I always have an image in my head. I can't remember how old I was, somewhere in the vicinity of 10 to 15 - I think earlier, 12 or 13. I went to Paris for the first time and visited Sacré Coeur. Whenever I play this Debussy I always remember getting this candle from Sacré Coeur which is about this tall and this thin [indicates with hands]. It was a red candle in a glass container and whenever I play this Debussy piece, I always think of that candle. It always just comes to me. I don't know why. I've never made the correlation.

This comment suggests a clear link to episodic memory, and while the Debussy piece in question was not an element of Ethan's initial memory, it is not difficult to draw a tangent connecting the music of Debussy, which stylistically epitomises French music, and Ethan's strong adolescent recollection of the burning candle in the Sacré Coeur Basilica in Paris. This description does not fit into the two previously mentioned categories of either nature or location; rather, the candle is an inanimate object. The link with episodic memory does, however, explain this difference. As a stereotypically French representation, this music appears to have foreseeably acted as a mnemonic trigger, and once established (focusing on the burning red candle) remained stable. The reported vividness of this imagery (as with the flowers associated with the Mozart *Sonata*) was strong, as Ethan did not describe the image as an impression of a candle, but rather that "there's a candle there". He described the

candle as being projected in his peripersonal space, with the image situated in his peripheral vision. Importantly, all of his reported examples of CVI are situated in this space, and Ethan described physically reaching for these images when he was younger; the fact that they were not 'there' would, in his own words, "freak me out a bit."

4.2.2.2.1.2. Case study 2: Charlotte.

In a similar way to Ethan, Charlotte described experiencing CVI in association with her synesthetic colours. Natural elements such as flowers were also present in her imagery, and – like Ethan - she also described a field of yellow flowers; the only differentiating element between her description and that of Ethan's is that hers is induced by music in C major (and not D major). This idiosyncrasy aside, their descriptions are strikingly similar, as Charlotte explains:

> CHARLOTTE: C-major is always yellow. I might be playing something in C-major and I usually get similar scenes playing in my head. It's a yellow scene but it might be looking at an open field with lots of flowers and the whole thing's sort of yellow…just like I'd see them in real life. Everything is almost like looking at a dream as well. So it's very much in my head but it's all coloured slightly differently. I could listen to that and I'd see that picture but I'd also know it was yellow. Everything looks yellow! [Laughs]

The scene Charlotte described is saturated with the synesthetic colour of the tonality of music she is listening to, yet the scene does not appear to be randomly induced. As a natural phenomenon, flowers are an obvious – albeit unconscious – choice for an

association with the colour yellow. This apparent pattern of non-random association is likewise indicated in the following music-imagery pairing:

> CHARLOTTE: They're all in these colours but it's almost like watching a movie at the same time. Quite often they're for particular pieces of music as well…A good example is whenever I listen to "Greensleeves" [a traditional English folk song], I'm looking at my feet on the ground covered in these dark green leaves. It's almost like walking through a forest. Everything's this brownish-green colour though.

In this example, the imagery initially appears to be mediated by the linguistic name of the piece: "*Green*-sleeves", rather than any particular musical element. The question, however, remains open. There does exist the possibility that early familiarisation of the piece in a particular tonality led to the coupling of the colour green with that tonality: a possibility supported by Charlotte's admission that a change in original tonality will drastically alter the look of the piece:

> CHARLOTTE: I have heard it transposed and it does make things strange. I'll start with the same image but it's almost like my brain's getting lost in trying to find a different colour. I remember hearing a jazz arrangement of "Greensleeves" and it was totally different. The picture changed. Everything changed to orange. It just wasn't the same.

From the above, it is possible to conclude that the original version Charlotte was exposed to acquired a colour from an early coupling of the original tonality with the

piece's title. If the piece is transposed, however, it will espouse the colour and imagery of the new tonality.

One final image provided by Charlotte involves a bell tower, which Charlotte indicated is a "dominant" image, and one that occurs frequently: "Other things, one that's really dominant is that I see a bell tower that's a greyish blue and there are doves coming out of it." While regularly concomitant with her music listening, this is also the image Charlotte experiences systematically during orgasms, and thus could be argued to be emotionally meaningful for her. Like all her other imagery, however, she is unaware of the meaning or provenance of the image and its corresponding colour. When describing her orgasm-image association she revealed:

> CHARLOTTE: Again, it's an image thing. So, at that point, that's the particular - that's the one that's really prominent. That's the bell tower thing that I see quite often and it's always light blue, almost like looking at white light. There's light blue around that and there are doves flying. That's what I see whenever that happens…It happens every time the same way, exactly.

The bell tower image is therefore automatic, involuntary, and stable, and is induced by both orgasm→colour and music→colour forms of synaesthesia. This image is furthermore memorable and detailed. This image, and indeed all of the images experienced by Charlotte, are unfamiliar, generic scenes, and do not relate to anything she recalls having ever seen before. There is a consistency to these images, which, like Ethan, are devoid of people.

The consequence of Charlotte's CVI on her musical decision-making is substantial, as she admitted: "Yeah, I find they tend to direct me. I will be drawn to something more if I had that reaction that was a nice colour or a nice picture." Understandably, the opposite is also true, with Charlotte admitting to disliking music that induces disagreeable colours or images. Charlotte furthermore described how the modulating musical stimuli would modify the imagery she was experiencing:

> CHARLOTTE: I remember playing Gaubert. It was initially like I'd start a phrase and I could see almost a ribbon unravelling in my head of the notes. But then it became fully fledged. It was almost like I could see this ribbon in different colours, changing with the music. Then it grew into a picture. Then I saw the paddock. With that piece, everything's got this yellow light over it. I can see it's very open as well. There are trees either side but they are sort of back, away from the image. I can see the sun and everything's yellow stained. I can see flowers everywhere and grass as well, but that picture also changes as that piece progresses. Sections of it become whole colours as well. I see that picture, but as it moves on, it becomes a light orange. It becomes light blue. When the piece concludes, it almost fades away entirely. So as soon as the music stops, it almost winds back down to that ribbon of colour. It's grown out of something. That's probably the best way I can describe it.

The above depiction of a piece by Gaubert is telling, as it clearly implies both a *perceptual* inducer (sound), and a *conceptual* inducer (awareness of tonality and form). The automatic association of individual notes with specific colours occurs both at the commencement and the completion of her experience of a piece. At the same

time, Charlotte's comprehension of modulations in tonality, form, and structural elements of the piece, provokes complex imagery. Both simple and complex visual imagery therefore co-occur within the same music-induced synesthetic process.

4.2.2.2.1.3. Case study 3: Matilda.

Matilda is not only a synesthete, but also the only AP possessor in this group of three. She described often seeing complex scenes when listening to music, particularly if engaged in mundane tasks, or in a relaxed state. The scenes she sees are either of nature or of a road, which she will travel down to the movement of the music. These scenes, once established for a particular song or piece, remain the same at every hearing of the piece, and are therefore consistent. Intriguingly, the scenes may take on the colour of the tonality the music is written in, but they may also take on the colour of the album cover or artwork that accompanies the piece. She depicted the colour of the album cover, for example, as often occurring in the "background" of her imagery: "Ah, yes. I'm actually thinking of an album right now. The album cover is mostly blue but it's in [pauses] E major. The whole album is mainly in E major. So, it's like a conflict between what I see on the cover and what I hear in my mind. So, they share, they share." The colour of the tonality and colour of the album cover thus often co-occur and blend within the same mental imagery.

When questioned on the natural scenes and roads she sees, Matilda was adamant these are places that are unfamiliar to her; rather, they are standard representations of these scenes. The scenes can be distracting, as she is incapable of switching them off if desired. Indeed, Matilda admitted she does not listen to her iPod before going to bed, as these scenes will distract her, and make falling asleep more difficult.

4.2.2.2.1.4. Key points of unfamiliar scenes.

The three case studies discussed above share two main commonalities. First, all three included both nature and location scenes, which were all described as unfamiliar. The one exception was Ethan, who described one particular scene – a church candle - clearly linked to an episodic memory from his adolescence. Second, all three indicated their CVI can be "distracting", which relates to the 'automatic' nature of their imagery, as it cannot be suppressed at will. This imagery only ceases when the inducer – in this case music – is eliminated. The imagery experienced by these participants was also reported as being influential in their interpretative decision-making, and while this could be a positive influence, it can also be restrictive. Similarities, however, end there. An investigation of the types of synaesthesia experienced by these synesthetes uncovered no striking resemblances between the three cases, or any unique features. Furthermore, neither Ethan nor Charlotte possesses AP, whereas Matilda does. The basis of their CVI therefore remains undetermined.

4.2.2.2.2. Familiar scenes.

Name	***Condition(s)***
Mason	Synaesthesia and AP
Lucas	AP

As noted in the introduction to involuntary CVI, two participants indicated they experience visual images of *familiar* scenes in response to musical stimuli. The first of these cases is both a synesthete and AP possessor, while the second only possesses

AP. In the following section, these two cases of CVI involving familiar scenes are examined and compared.

4.2.2.2.2.1. Case study 4: Mason.

Mason has both multiple forms of synaesthesia, including colour and taste percepts inducted by music, as well as AP. Mason made it clear he does not see what could typically be described as Klüver's form constants, yet indicated he does "sometimes have memories" which he involuntarily associates with a particular musical piece. At first glance this appears to be a reliable description of music serving as a retrieval cue in the case of episodic memory. Indeed, Mason acknowledged that this might be the reason for his imagery, yet countered this assumption by indicating that the scenes he sees – although often of familiar places – will have no conscious or evident connection to the music he is hearing. Mason thus distinguished music as a catalyst for episodic memory from the CVI he experiences, and described the places as recognisable visual scenes, lacking people, and also lacking situations or events. The scenes are also generally of empty spaces, such as a street, school ground or natural scenery, and might include physical objects such as buildings. While the imagery does not occur with all music, he did indicate that once an association has been made between a specific piece and a specific visual scene, that association remains stable:

> MASON: Recurring, yeah. So, there might be a specific piece of music and then, at a particular spot, I'll always get taken back to a specific location that I was at once.

While Mason indicated these scenes are inherently uncoloured, they *are* imbued with the associated synesthetic colours induced by the tonality and instrumentation of the music he is listening to. His synesthetic percepts thus override and take precedence over any colours he would typically recall in association with the places and locations he experiences.

4.2.2.2.2.2. Case study 5: Lucas (absolute pitch possessor).

All four of the above-mentioned cases of CVI were reported by participants with synaesthesia. One case of CVI was reported by a participant with AP: Lucas. Lucas does not have synaesthesia, yet the way he described his AP as having a spatial location (i.e. a 'real life' spatial location, whereby the music transports him to an outdoor place he is familiar with) is evocative of how synesthetes in this study have depicted complex scenes. As with the other cases of involuntary CVI noted above, Lucas described these scenes as being devoid of people:

> LUCAS: I experience music happening somewhere…some space or a location around the city…I imagine them being [pauses] not performed anywhere, but when I hear a piece of music, I'm taken mentally to another place in the city and it's usually to places where I've been. I don't know why that happens.

When asked to describe these locations, Lucas offered the following illustration:

> LUCAS: Within Melbourne city, yeah - sometimes in the suburbs. It's a very hard concept to describe. I've never told anyone that before [laughs] … With a Prince song that I know, I visualise being at - not performed at - but I'm just

> taken to a particular intersection in the suburbs of Melbourne. For that entire song, I'm just viewing this intersection from different angles. Often, I'm moving through this intersection and then moving back through it in the same place, over and over again throughout the duration of the song. I'm not sure why.

Lucas's first recollection of this associated locational imagery extended back to the age of 9, with him conceding that it has continued ever since. Of particular interest was his admittance that this imagery does not appear with classical music (the enjoyment of which was recent for him), but that it "almost always" occurs with pop songs – particularly repertoire that he listened to during his childhood and adolescence.

The vividness of Lucas's CVI is illustrated in the following example:

> LUCAS: There's no people, interestingly - it's always empty. But everything about the streets - the tram tracks, the power lines: everything. Just about every detail, the trees surrounding the intersection…colours as they appear when you would see them in real life with your own eyes.

The pictorial representations described by Lucas are similar to the locational images described by Mason (above). It is essential to note one particular difference however, in that Lucas sees colours in his scenes (which he described in vivid detail, as they appear in "real life"), whereas Mason does not. Mason is, however, a synesthete, and thus the scenes are blanketed with the synesthetic colours he experiences

accompanying the music. This is likely to be why he is unable to see the scene as coloured, as his synesthetic colour percepts override the colours that would normally be attached to his memory of each particular location. As Lucas does not have synaesthesia, the colours he would normally recall as being attached to the specific known scenes remain intact.

4.2.2.2.2.3. Key points of familiar scenes.

Both cases of CVI involving familiar scenes were reports from AP possessors, while the first (Mason) is also a synesthete. The appearance of CVI in a non-synesthete AP possessor (Lucas) is noteworthy. The involuntary yet stable interaction of music and images in the descriptions outlined by both Mason and Lucas are mediated by episodic memory, yet do not appear to be instances of music acting as a retrieval cue for these memories. While familiar, the locations and settings of these images are devoid of meaning or emotional attachment for Mason and Lucas, and moreover have no connexion to the music that is inducing them. Both cases noted the lack of situation in the observed scenes, and the sense of being observers of, or moving through, the scene in highly repetitive behaviours. The only substantial differentiating characteristic between these two cases is the colour saturation of the scenes. As a synesthete, Mason's scenes are coloured by his synesthetic percepts, which override any inherent colours, whereas for Lucas his visual scenes are vibrantly coloured, as one would expect to see in "real life". The vividness of the colour percepts in both cases is, however, acute.

4.2.2.2.3. Key points of involuntary complex visual imagery.

Five cases of self-reported CVI were reviewed in the above section: three of unfamiliar scenes, and two of familiar scenes. Two of the cases were non-AP possessing synesthetes, two possessed both synaesthesia and AP, and one was a non-synesthete AP possessor (see Table 4.3).

Table 4.3
List of participants who reported experiencing complex visual imagery (CVI) in response to music

Name	**Scene Type**	**Syn/AP**	**Types of images**	**Memory Link**
Ethan	Unfamiliar	Syn	Nature, Locations, Objects	Yes
Charlotte	Unfamiliar	Syn	Nature, Locations	No
Matilda	Unfamiliar	Syn/AP	Nature, Locations	No
Mason	Familiar	Syn/AP	Nature, Locations	Yes
Lucas	Familiar	AP	Nature, Locations	Yes

Note. 'Synaesthesia' has been abbreviated to 'syn'.

The complex and pictorial images described in these cases are automatic, involuntary, and unable to be suppressed. Additionally, all of the cases reported consistent and stable mappings between specific musical stimuli and the complex imagery they induced. An analysis of the cases within these two subgroups uncovered no distinguishing characteristics that would differentiate those who reported visualising unfamiliar versus familiar scenes. Of the three participants who described at least one instance of imagery linked to a specific memory, these examples were not musically mediated episodic memories, as the scenes in question were not linked to the music in any known or discernible way. Furthermore, there were no distinguishing characteristics between participants who reported CVI, and those who did not. The reason for the appearance of CVI in these five cases is therefore unclear.

4.2.3. Summary of Imagery

To summarise, synaesthesia and AP were recurrently reported as enhancing music related imagery. In the analyses of the results, unimodal and multimodal forms of mental imagery were examined separately. From a unimodal perspective, synaesthesia and AP were reported as enhancing auditory imagery (AI), with a cumulative percentage of 71.4% (n=25) of participants noting their AI was as strong as hearing music from an external sound source. Within this group, ten participants (28.6% of total number of participants) reported that their AI could block out external sounds. The vividness of the AI experienced by these participants was reported as being indistinguishable from heard music. Differentiation was noted, however, as being due to both the ability for live music to 'surprise', and due to the participants' reported 'control' over the imagery process, including the speed and volume of their AI. Heightened AI was reported as having perceivable benefits on musicianship skills, such as composition and sight-reading. Both synesthetes and AP possessors reported heightened AI, with no notable differences between groups.

In the context of multimodal mental imagery (MMI), two themes were analysed. First, cases of AI triggering synesthetic percepts were reported, as was a case study of synaesthesia potentially triggering AI. This bidirectional analysis of AI and synaesthesia suggests that not all MMI requires sensory stimulation. Second, unexpected cases of complex visual imagery (CVI) induced by musical stimuli, were presented. The complex and pictorial images were described as automatic, involuntary, and unable to be suppressed. These images were furthermore reported as being consistent and stable mappings between specific musical stimuli and complex

imagery. Between participants who reported CVI, and those that did not, no distinguishing characteristics were identified.

4.3. Summary of Cognition

An analysis of the interview data obtained from the musicians in this study revealed that synaesthesia and AP considerably impact the cognitive outcomes of their musical development. Two cognitive domains – memory and imagery – were repeatedly reported as being substantially enhanced by the possession of synaesthesia and/or AP.

Music memorisation was overwhelmingly reported as being enhanced by synesthetic percepts and AP associations, which provide richer worlds of experience, aid in the organisation of musical memory, and offer possessors retrieval cues for musical material when performing. Accuracy and speed of music memorisation was reported as being enhanced by the possession of either condition, while AP possessors also frequently described using pitch-memories, embedded in a 'sound bank', as part of a pitch-labelling strategy.

Auditory imagery and music-induced visual imagery were recurrently reported as being influenced by synaesthesia and AP. The vividness of auditory imagery (AI) was noted as being enhanced by these two conditions, as was the ability to control the speed, dynamics, and intensity of the imagery. Benefits directly associated with the heightened vividness of AI were also described. A bidirectional analysis of the functional relationship between AI and synaesthesia ascertained that multimodal mental imagery (MMI) could be triggered by AI, thus bypassing the need for sensory stimulation. Furthermore, cases of complex visual imagery (CVI), reported in this

study, were confirmed to meet the synesthetic diagnostic criteria of being automatic and involuntary, as well as being consistent and stable mappings between specific musical stimuli and complex imagery. These findings are noteworthy because they call into question the general assumption that synesthetic percepts are generic and simple in nature.

Overall, the intersection between music memorisation and various forms of imagery was described. Synaesthesia and AP were repeatedly reported as considerably enhancing various aspects of the cognitive process of musical development. In these aspects, reports from synesthetes and AP possessors were comparable, with no distinguishing characteristics identified. In the following results chapter (Chapter 5: 'Affect'), the affective outcomes of synaesthesia and AP on musical development is reported and analysed.

Chapter 5

Affect

This chapter examines two interconnected affective domains: motivation and identity. While it is understood that the broad categorisation of motivation and identity as 'affective' domains is imperfect, this classification was chosen to best reflect the terminology and underlying orientation and emphasis of participants' responses. The possession and unique experiential aspects of synaesthesia and absolute pitch (AP) on the affective outcomes of musical development are therefore examined through an exploration of how these unique perceptual experiences affect possessors' motivational drive, beliefs, attitudes, and self-regulatory processes, and the role of synaesthesia and AP on the formation and maintenance of a positive musical identity.

The first section of this chapter investigates the impact of the possession of synaesthesia or AP on participants' motivation to study music. Descriptive statistics concerning the influence of synaesthesia and AP on participants' motivation to study music are analysed, and the role of synaesthesia and AP in enhancing participants' relationship with music, purpose and direction, and autonomous regulation and competence, is examined. The following section explores the impact of synaesthesia and AP on identity formation, cases of increased popularity and a heightened sense of pride due to the possession of one or both conditions, and the frequently reported feelings of fear or trepidation at the thought of the potential loss of their condition(s).

5.1. Motivation

"It definitely motivated me to continue with this because especially knowing that it was rare and even discovering it now - really discovering how rare it really is - it just made me think - this is a sign. This is something really special about me that I need to continue doing because I can't let this go. It's a sign."

William (AP)

The following analyses explore the role of synaesthesia and absolute pitch (AP) on participants' motivation to study music. As a process, the term motivation is used to understand why a specific behaviour is instigated, and how that behaviour is sustained over time (Evans, 2016; Schunk, Meece, & Pintrich, 2014). The focus of motivation research is therefore on what "moves people to action" (Ryan & Deci, 2017, p. 13), including what gives direction to a specific behaviour, how this behaviour is energised, and the learning and performance outcomes of these processes (Ryan & Deci, 2017). Motivation theories address how peoples' cognitions, beliefs, attitudes, and identities interact to influence behaviour, as well as how environmental influences and social interactions impact these complex self-concepts. Motivation is therefore derived from multiple sources, often operating simultaneously to impact both the quality and dynamics of behaviour. Two contrasting, yet often simultaneously operating types of motivation can be delineated: intrinsic and extrinsic. Because the focus of this study is on personal cognition, affect, and behaviour, only intrinsic motivational forces are examined.

This section is divided into two subsections. First, a review of the descriptive statistics obtained from the quantification of interview questions, regarding the influence of synaesthesia and AP on participants' levels of motivation to study music, is undertaken. This question was asked regarding both the commencement of the participants' formal musical training, and also in regard to their musical studies at a tertiary level.

Examples of synaesthesia and AP acting as intrinsic motivators form the second part of the analyses. This section is subdivided into three parts: the possibility for synaesthesia and AP to enrich relationships with music, by enhancing both the enjoyment of music, and the connection to music; the potential for synaesthesia or AP to provide purpose and direction to possessors, such as either condition being viewed as a 'gift' or a 'sign'; and the impact of synaesthesia and AP on autonomous regulation and competence through the potential for these conditions to influence self-directed learning.

5.1.1. Descriptive Statistics of Motivation

Participants were asked two questions regarding the influence of their synaesthesia and/or AP on their music related motivation: whether their condition(s) influenced their decision to *commence* formal musical training (usually during early childhood), and whether their condition(s) influenced their decision to *continue* musical training at a tertiary level. The distribution of responses to these two questions is outlined below.

5.1.1.1. Motivation to commence musical training.

The impact of synaesthesia and AP possession on the motivation to begin formal musical training was weak, with only seven participants (20% of total participant group) noting an effect of their condition(s) on their motivation to commence music training (see Figure 5.1). Of these, two participants (5.7% of total participant group) indicated their AP was a key factor in their desire to begin musical training. For the remaining participants, the main factors reported were access and opportunity. Participants regularly indicated the commencement of their formal musical training was either a parental choice, or contingent on access to a particular instrument or music program. Other participants stated it was a personal desire, modelled on the musical practices of a parent or older sibling.

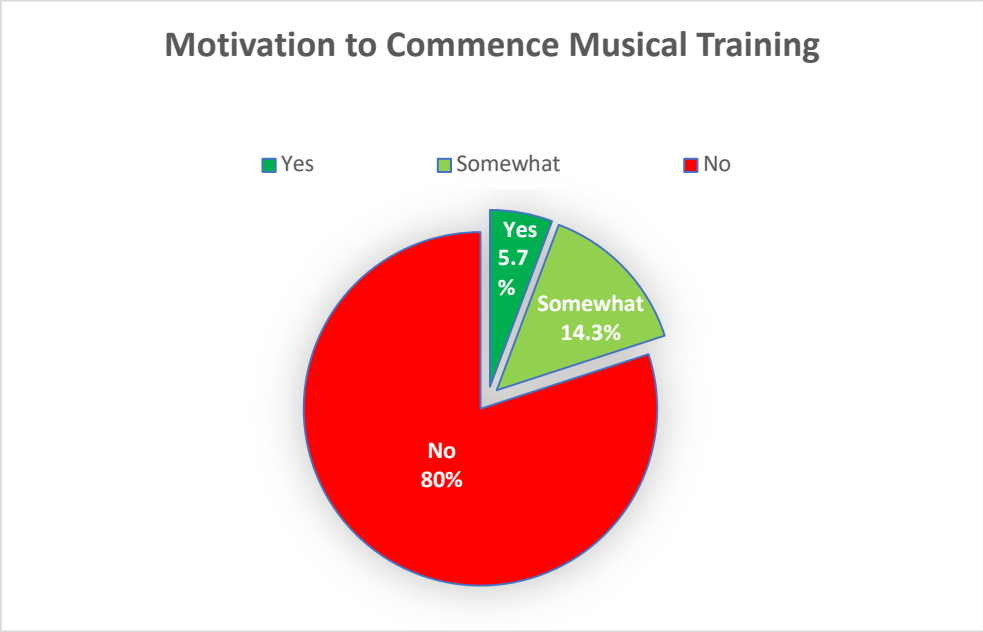

Figure 5.1. Percentage of overall participants who indicated the knowledge of their condition motivated them to commence formal musical training.

5.1.1.2. Motivation to continue musical training at a tertiary level.

While the impact of synaesthesia and AP possession on participants' motivation to commence formal musical training was weak, the effect was noticeable when

discussing motivation to continue formal musical training at a tertiary level. Twenty-two participants (62.9% of total participant group) noted an effect of their condition(s) on their motivation to continue music training at a tertiary level, and of these, nine participants (25.7% of total participant group) indicated their synaesthesia and/or AP was an important (or indeed the *most* important) motivational drive (see Figure 5.2).

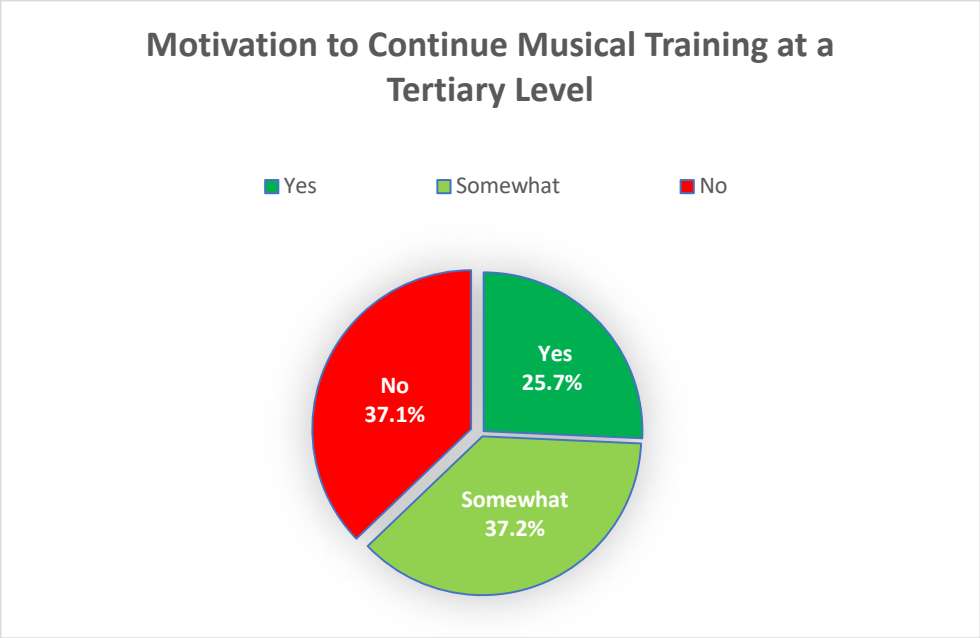

Figure 5.2. Percentage of overall participants who indicated the knowledge of their condition motivated them to pursue musical training at a tertiary level.

In summary, the possession of synaesthesia or AP was reported as a motivational factor to continue musical studies at a tertiary level by 62.9% of participants. The mechanisms behind this motivational drive are examined in the following section, where an investigation of the impact of synaesthesia and AP on intrinsic motivation is undertaken.

5.1.2. Intrinsic Motivation

"People tell you, you can't make a living out of music, but I definitely felt an affinity with music and studying it and persisting. I felt that I had some sort of connection."

Charlotte (Synaesthesia)

The impact of synaesthesia and absolute pitch (AP) on intrinsic motivation was examined based on the data collected during the interview process. The interview procedure sought to gather information concerning the possibility for synaesthesia and AP to enrich relationships with music, the possibility for synaesthesia and AP to provide purpose and musical direction, and reports from synesthetes and AP possessors concerning the belief in their condition(s) as a 'sign' or 'gift'. The analyses conclude with narrative examples from participants of how intrinsic motivation manifests as autonomous, self-directed and driven music participation, and the ability for AP to act as a practical aid in music related tasks, thus increasing feelings of competence.

5.1.2.1. Relationship with music.

Music participation involves tasks that are to a large degree intrinsically interesting and can thus been engaged with in and of themselves as 'rewards'. The enjoyment of these tasks can generate intrinsically motivated behaviours, that are rewarded by "spontaneous feelings of effectance and enjoyment that accompany the behaviours" (Ryan & Deci, 2017, p. 14). Individual differences in intrinsic interest do exist, however, as individuals exhibit distinct, but relatively stable, levels of intrinsic enjoyment of music related tasks (Evans, 2016). These differences can be theorised as

potentially resulting from stable traits such as personality, genetic differences, or – as might be the case here – from specific neurological conditions. The question that therefore presents itself is: do synaesthesia and AP modify feelings of enjoyment of, or connection to, music?

5.1.2.1.1. Enhanced enjoyment of music.

Name	***Condition(s)***
Xavier	Synaesthesia and AP
Mason	Synaesthesia and AP
James	Synaesthesia and AP
Charlotte	Synaesthesia

Synaesthesia and AP were reported as providing additional enjoyment to music-related tasks and can therefore be identified as stable and consistent enhancers of *intrinsic interest* in these tasks. As synesthetic percepts and AP associations for music related tasks are relatively established across the lifespan, and in general present for as long as the possessor can remember, these associations constitute a core difference in intrinsic interest in these activities that is founded on their heightened sense of enjoyment. Even tasks that may not initially appear to hold much intrinsic interest, such as scales or technical work, are automatically perceived as more enjoyable, due to the associated synesthetic percepts or AP associations that accompany any form of pitched-sound production.

From the perspective of synesthetes in this study, music-induced synesthetic percepts were noted as adding “beauty”, “vividness”, “enjoyment”, “feeling”, and even a further “dimension” to the musical experience. For Xavier, for example, synaesthesia

is “such a big part” of his musical life as it draws music onto a “whole new level” for him. Music is no longer restricted to just the one, auditory sense:

> XAVIER: The synaesthesia: the best part about it, is that music's on a whole new level to me; it's not just about one sense. Even though I'm not visually directly seeing it, I still associate it with that. I feel it excites more than just that auditory sense. It's a lot more than just sounds to me. That's why it's such a big part of my music life. … I'm very grateful for it. I think I wouldn't enjoy music as much if I didn't see the colours because it's more than just a sound and playing. Now it's also visual. So it's that combination of all that that really makes me enjoy it and excites me about it. So it's definitely very positive. I associate that colour with…I find it adds a bit more to the beauty of it, just because you've got something that you're visually seeing now as well, so it helps with that.

Heightened enjoyment of music related tasks triggered by synesthetic percepts was reported in this study to increase motivation to engage with these tasks at both an initial stage of music training during childhood, and also at a tertiary level. Charlotte, for example, indicated her synaesthesia amplified her motivation to begin music training as a child; it was her enjoyment of the associated synesthetic colours that particularly drew her to music: “I feel like it always motivated me to get involved in music though and based on the fact that there was music around my house and I always felt like there was a colour associated with it and I liked it then. It did motivate me to start being part of music.”

At a tertiary level, Mason provides a particularly strong indication of the role that synaesthesia played in his decision to continue his musical studies:

> MASON: Quite a big degree because synaesthesia is what, for me, gives the music its characteristic. I try to picture if I didn't have synaesthesia, would music have the same effect, or would it just be hearing a bunch of notes that have no meaning behind them? ... Yeah, that's what I think: the synaesthesia's what makes it meaningful and what makes it enjoyable to listen to or to play.

The multidimensional aspect of music, inherent in the synesthetic experience, was discussed by Mason:

> MASON: That ability for the music to become more personified and to come alive with the associated colours. It gives the sense that it's more three dimensional and not so much flat. This is not talking physical shapes, but just the idea. It becomes deeper. You have more of the sense of travelling and journeying through it.

Mason indicated his synesthetic percepts do not “create emotion”, even though they do deepen both his appreciation and understanding of the music. As Mason has both synaesthesia and AP, his AP plays a role in this enhancement, by providing him with a “sense of structure like where you're heading - heading away from the tonality and coming back to it… a sense of the hierarchy - what's more important, and also the intensity of being really far away from the home key”. For Mason, his synaesthesia

and AP combine to impart a heightened state of musical enjoyment, which in turn enhances his motivation to continue musical studies at a tertiary level.

Like Mason, James has both synaesthesia and AP, but noted it was his AP (and not synaesthesia) that provided him with an advantage and "different perspective from everyone else." He reported his AP makes his "whole learning process … much more enjoyable." James noted his heightened sense of musical enjoyment, afforded by his AP, increases both his perceived level of competence, and the intrinsic interest gained from engaging in music-related tasks.

5.1.2.1.2. Enhanced connection to music.

Name	***Condition(s)***
Benjamin	Synaesthesia and AP
Chloe	Synaesthesia and QAP
Olivia	Synaesthesia and QAP
Charlotte	Synaesthesia
Liam	AP

Synaesthesia and AP were reported as facilitating the establishment of a deeper connection with music than participants believed would be imaginable without the possession of their condition(s). An enhanced connection to music, with a "richer" appreciation of musical experiences, is a theme that underscores both the synesthetic and AP experiences reported in this study. A evaluation of how synesthetes and AP possessors describe the influence of their conditions on their relationship with music illustrates this point: as a synesthete, Chloe noted that the "best thing" about having synaesthesia was that her "connection with the music is a lot deeper and more meaningful…connecting and understanding the music in a way that's far more meaningful than it would be without [synaesthesia]." This sentiment was mirrored by

Liam, who as an AP possessor noted his AP gives him "a higher sense of knowing certain things about the score, about the music and maybe a deeper connection with the sound that you produce, a deeper connection with the sound that other people make."

The deeper connection or affinity with music reported by participants provided a strong motivational drive. From the perspective of synaesthesia, both Charlotte and Olivia reported feeling motivated by their enhanced connection with music. Charlotte noted, "People tell you, you can't make a living out of music, but I definitely felt an affinity with music and studying it and persisting. I felt that I had some sort of connection": a connection she ascribed to her unique perceptual experience of music. For Olivia, this motivational enhancement operated at a subconscious level, though she is now able to observe its impact on her decision to pursue a career in composition:

> OLIVIA: Maybe at a very, very unconscious level, my deep connection with music has something to do with the colour and the familiarity from associating with that music in a colour and pitch sense. Maybe it unconsciously plays a part. I don't think it's that conscious…I think it probably does play a part. My motivation to engage with music is about my personal connection - a very deep personal connection with the music. I guess that connection is about colours, tones, expression and melody. I just love melody, different sounds, sound colours and things.

For Olivia, therefore, her connection to music is mediated in part by her synesthetic colour associations, which in turn influenced both her musical development and motivation.

Absolute pitch possession can also provide a deeper perceived connection to music, as described in detail by Benjamin. Benjamin listed the "deep engagement with this sound world that I can access at any time" as the most important aspect of his AP ability:

> BENJAMIN: I feel that because of the AP, when I listen to, play or think about music, it's like I'm stepping into a world. It's not a thing; it's not an activity that I do. It's not like watching television…It's a very strong sense of stepping into a world and - it sounds so corny to say it, I know - but the keys are my friends. That's really how it was for me when I was young, and I didn't have any friends. At playtime, I didn't have any friends, so I used to walk around the perimeter of the school playground, singing to myself. If someone came up to me, I'd say, "I'm composing a sonata today; or I've just written a symphony in my head. It sounds exciting. Do you think I should use a piccolo here? Buzz off!" But yes, they're like friends. It's a very distinct world that I can step into and it's a world that I understand much better than the actual world [laughs] - people, whatever.

Benjamin insisted this relationship is enabled by, or "because of", his AP. His early affective attachment to keys as his "friends" is a confluence of several factors: his AP, synaesthesia, autism, bullying, isolation, and depression. Music is for him a "safe

place", and one that he would go to at lunchtimes or after school for many hours. It is easy to understand why he stated this sound world is a world he understands "much better than the actual world" (referring specifically to other people). Indeed, Benjamin's reported connection and relationship with music was a recurring and underlying theme during his interview. He referred to his "special connection" on numerous occasions, including in relation to his reason for commencing musical training as a child:

> BENJAMIN: [Pauses] Obviously I don't know but I have thought about this a little bit and I've talked to her [mother] about it as well. I think it was to do with the connection with music…she will tell me that when she was pregnant with me (when she was giving a piano lesson) if I was kicking about - as soon as the music started, I would settle down. That happened when I was a baby as well. Any time there was music, I was calm. So, it was the connection with this thing that I had always known, even before I was born.

Benjamin therefore has a deep-seated belief that his strong engagement with music was present even before he was born. When questioning turned to his tertiary education, he noted, "I decided when I was six that I wanted to study music at a tertiary level and that I wanted to do musicology. I'm just doing now what I'd planned out to do when [laughs] I was six." Indeed, his desire to study musicology was inspired by a strong connection he felt as a child to the narrated lives of composers:

> BENJAMIN: I feel like I'm having an interaction with the composer on a personal level, and particularly composers that I love. I think that's also why

> I'm so interested in musicology and the lives of composers and I have been. People who were like me, people who were a bit different (I'm not comparing myself to Mozart, but -) it was like when I was a small child these [laughs] dead people understood me. They were writing pieces that I could connect to and they were speaking to me through the music. I was finding out more about their lives and wow, Mozart started out when he was young like I did and this, that and the other. I'd have much preferred to be friends with Mozart rather than that person in my class. So, it's like having a personal connection. It sounds a bit morbid, I know, but having a personal connection to the composer as well.

Thus, as well as referring to individual keys as “friends”, Benjamin similarly references past composers, with whom he feels a strong connection. The relationship with music he frequently mentioned was thus expanded to include the composers of that music, with whose lives Benjamin perceives a certain degree of similarity and familiarity. This certainly enabled him to feel a sense of belonging, in a world he otherwise found difficult to navigate.

The duration and strength of Benjamin’s motivational drive was similarly evident in conversation with Cooper, who likewise indicated knowing from a young age that he wanted to pursue a career in music: “I'm not sure about starting musical training, but certainly continuing it…I think AP has been a factor for a long time with pursuing music. I knew from quite a young age, perhaps from Grade 5 or 6 that I wanted to be a composer. So, from that stage, it was like, "Yep, that's what I'm going to do: I'm going to continue with music in that sense." I'm sure AP was a factor in that sense.”

As a longitudinal and ongoing connection with music was reported as being facilitated by the possession of AP for both Benjamin and Cooper, it is evident that the stability of their internal motivational drives was intimately linked to their unique relationships with music. Indeed, Benjamin acknowledged he may not have studied music at a tertiary level if he did not have AP: "I probably just don't think I would have the extremely personal engagement with music that I do that drives me anywhere and everywhere." AP ability is thus the cornerstone upon which rests his deep musical engagement, and thus provided a strong motivational drive to pursue music studies at a tertiary level.

5.1.2.1.3. Key points of relationship with music.

Synaesthesia and AP have been established as potentially enhancing the enjoyment, connection, engagement, and relationship with music, and thus heightening intrinsic motivation. Synesthetic percepts and AP associations were reported as adding an extra dimension to musical experiences, including an enhancement of music's beauty, vividness, and feeling. These added dimensions were furthermore reported as positively influencing possessors' engagement and relationship with music.

5.1.2.2. Purpose.

This section considers the potential for synaesthesia or AP to provide purpose and direction to possessors, such as by influencing their choice to pursue musical studies at a tertiary level. During the interviews, synesthetes and AP possessors reported believing in their condition(s) as a 'gift' or 'sign', in either a spiritual or religious sense. The effect of these beliefs on participants' motivation to pursue studies in

music was highlighted in four cases of career changes back to music, in which these individuals spoke about possessing a special 'gift'. Reports from these individuals also outlined their desire to not 'waste' their perceived 'gifts', thus motivating them to pursue musical studies at a tertiary level.

5.1.2.2.1. Synaesthesia and absolute pitch as a 'sign' or 'gift'.

Name	***Condition(s)***
Mason	Synaesthesia and AP
James	Synaesthesia and AP
William	AP

The rarity of both synaesthesia and AP can be construed as a 'sign' or a 'gift', compounding the perception of being 'special' or 'unique', thus offering a strong motivational drive. Mason, who has both synaesthesia and AP, indicated feeling a "sense of privilege and luck" at having these conditions. Describing his synaesthesia in particular, he indicated feeling "privileged" to have this "special quality", while also feeling quite "smug". This notion of having been given a 'gift' can also incorporate spiritual connotations. James, for example, indicated believing he was born with AP, noting:

> JAMES: With the idea of having perfect pitch, it gave me - I don't mean to sound arrogant but - it did give me some sense of pride. It was shortly around the time that I started to accept the fact that I was autistic. I really began to learn a lot about myself. I was really open about it with my friends. My perfect pitch began to blossom. As a result, I could now say to people that perfect pitch was something I'd derived from autism. As a result, it made me really proud to be who I am. For those who believed, God gave me a gift or I was

> born with a very special ability for such and such. I became very proud to be who I am."

Whether by a divine deity or not, James does believe his AP is a gift that was given to him, that he is "excruciatingly lucky" to have it, and that "not a day goes by that I don't appreciate being who I am and this gift that I was given."

Like James, William indicated the belief that possessing AP is "a sign", which is underpinned by a religious or spiritual understanding of where this "gift" came from. The spiritual provenance of this gift was a particularly strong motivational factor in his decision to study music:

> WILLIAM: It definitely motivated me to continue with this because especially knowing that it was rare and even discovering it now - really discovering how rare it really is - it just made me think - this is a sign. This is something really special about me that I need to continue doing because I can't let this go. It's a sign [laughs].

William believes he was born with this gift, and that it is not something he had to learn; it is, nevertheless, something he needed to "continue doing". He furthermore acknowledged that the best thing about having AP is that it is "so rare", which is "something that's defining me because it's so rare." He also indicated he "wouldn't have it any other way", as "it's who I am. I was born with it." Absolute pitch is thus central to his identity, with the rarity of the condition adding to his emotional

attachment to it: “Speaking about it now, it defines who I am. So, I think it is more so now - more of a powerful emotion for me, now that I'm realising how rare this is”.

5.1.2.2.2. Career change motivated by a ‘gift’.

Name	***Condition(s)***
Xavier	Synaesthesia and AP
Chloe	Synaesthesia and QAP
Sophie	AP
Max	AP

After having completed undergraduate degrees in an unrelated field, four participants subsequently enrolled in postgraduate music studies at the Melbourne Conservatorium of Music. All four reported their conditions (synaesthesia in the case of Chloe and Xavier; AP in the case of Sophie and Max) were key contributing factors in their decision to return to advanced music training.

The idea of not having synaesthesia is unimaginable for Chloe. She described how she was able to complete the whole of her first year’s undergraduate aural training work in just three weeks but would later drop out of her degree at the Conservatorium, only to return to music studies several years later. She believes the “extra dimension” music acquired thanks to her synaesthesia may have played a role in the professional direction she eventually took: “So maybe if I didn't have that extra dimension because of my synaesthesia with music, I might have tried to go in a writerly direction or solving people's problems [laughs]. I might have gone in that kind of direction.” Like Chloe, Xavier indicated his synaesthesia was an important factor in his decision to continue his studies in music:

> XAVIER: It definitely played a part - a big part. I felt like not everyone has this, so I'm very lucky to have this extra sense that will allow me to enjoy music more. It's always has been a big factor in my enjoyment of it. So definitely. It was one of the reasons. I did music at school and then I went and did an engineering degree. I still played music and did my AMusA at the time, but I felt like it helped me make that choice to come here because I felt that since not everyone has it, it might be a bit of a sign to do something along those lines; to use it for something. So, I definitely see it as one of the factors that brought me here.

After initially completing a degree in Engineering, Xavier felt his synaesthesia was "a sign" to radically change career paths and pursue an activity that would put his 'gift' to good use. Moreover, Xavier also reported his synesthetic percepts considerably heighten his enjoyment of, and engagement with, music in general:

> XAVIER: I definitely think I would lose a lot from not having those colours. Maybe not the AP; I could get away with not having that. But definitely the colours - I would lose a bit of beauty and what I see in the music. I probably would not have pursued music because that has been a big part of me developing as a musician, having that and keeping things exciting with colours flying around. It always keeps me engaged. I would say I would probably not have pursued it - that's more a factor. It would definitely be a big part.

Hence even though Xavier has both synaesthesia and AP, he signalled out his synaesthesia as the decisive influence on his decision to pursue a career in music (see

also Appendix A: 'Xavier'). Indeed, of the 11 participants with both conditions, he was the only one who did not specify that his AP is his dominant condition (see Chapter 7, Table 7.1). Xavier's synaesthesia was thus fundamental to his decision to ultimately pursue a career in music.

Analogous examples of this motivational enhancement can be found in descriptions provided by AP possessors. Sophie, for example, regards her AP as a "gift". She believes AP contains a "genetic element", and that she was "born" with it. For Sophie, her ability is a gift imparted by a religious deity, thus adopting the idea of a 'higher' power or purpose designating the career path she should be taking. Not only did this special gift motivate her to study music, it was instrumental in her "motivation to change directions completely", after completing an initial degree in computer engineering:

> SOPHIE: I guess that having AP makes me feel like I should really do something about music because it is sort of like a gift. It really does make learning less effortful. [Pauses] Even when I was doing computer engineering, I was in an a cappella group and I transcribed quite a number of a cappella music. Having AP was really helpful for that. It makes me happy to do that and it makes me happy to use this ability and be involved in music. That was my motivation to change directions completely.

A second AP possessor who noted the influence of his AP possession on his motivation to return to music training, after an initial degree in Commerce and Law, was Max. For Max, AP provided him with "security". He is heavily reliant on his AP,

which is entrenched in his musical thought process, and is rooted in his belief that he was born with the ability. Max admitted he "wouldn't know how to function without it", and cannot envisage how he would understand music, if he did not have AP.

5.1.2.2.3. Wasted 'gifts'.

Name	***Condition(s)***
Lucas	AP
Alexander	AP

The notion of viewing synaesthesia and AP as 'gifts', as frequently expressed by participants in this study, was expanded to include the rationale that not pursuing a career in music would be a "waste." Notably, Lucas indicated it was his father who initially suggested this relationship: "My dad had hinted that if I pursued music, I would do better than others on the basis of my perfect pitch. He said that's a reason that I should go for music…He thought it would be a bit of a waste if I didn't pursue music, not because he did music himself but if I have perfect pitch and I have an ability to sing, I may as well use it." As with Lucas, Alexander also benefited from a highly supportive environment, which led to a great deal of praise being bestowed on him. The uncommonness of his ability was often signalled out to him, leading to a feeling of uniqueness, and in particular a sentiment that his unique skill was not to be wasted. Alexander confirmed this by stating, "It just feels like I'm a little more gifted than others. I feel that I shouldn't waste this, and I shouldn't just take perfect pitch as, "Oh yes, perfect pitch: it's just something I know."" Alexander described AP as a substantial part of who he is as a musician and divulged he does not share this information with many people. Even his teacher is not privy to the level to which AP is important and personally influential to him. AP is a part of the "engine of the car"

and is therefore ‘driving’ his musicianship. When asked to what degree his AP motivated him to continue his studies in music, he responded:

> ALEXANDER: Very high. I always think about it - as I said - it is very personal, I think. I really feel that it's part of it. It's part of how I play the piano, which many people don't really know. My teacher knows I've got perfect pitch, but he doesn't really talk about it. To be fair, with him, I don't think he doesn't care about it, he just doesn't really want to go deeper into it. He thinks, "That's great that you've got that. It's a great talent, but it's not everything." I feel it's more than just that. I feel that it really helps with my memory, with knowing everything and just being able to really hear what people are doing and quickly know exactly what's happening. So, it's really…it’s part of the engine of the car. It's not just a minor part of the car. It's actually part of the engine, if that's a good metaphor to use.

We are immediately reminded of Alexander’s previous metaphorical employment of the concept of an ‘engine’ in his description of his AP ability (see Chapter 4.1.2.1.: ‘Absolute pitch as a mnemonic aid’). What this depicts is the intensity with which his musical identity is ascribed to his AP ability, with Alexander further stating: “So I know I'm more than other people: I have this talent and most people don't.” This ‘other vs. I’ discourse, through which he views his ability and musical status, is evident in his persisting portrayal of his AP as an “extra ability” and “special”. At one stage of the interview Alexander appeared to appeal to his fellow AP possessors, stating, “Those of you who have perfect pitch, you should feel special having it. You shouldn't waste it.” He followed this by stating:

> ALEXANDER: I think if you're especially a musician and if you have this ability: perfect pitch, and if you know it and you know how to use it, it's doing something with your learning process. You shouldn't waste it. I feel that it has done a lot for me. It has helped me all the way and it's still doing something all the time with all the things that I've mentioned earlier. I don't think it's something worth wasting, certainly not.

As previously reported by Lucas, the idea of potentially "wasting" this AP ability if it is not harnessed and developed was also a theme that was frequently expressed during Alexander's interview.

5.1.2.2.4. Key points of purpose.

A synesthete or AP possessor's belief that they have a rare or even God-given gift can considerably enhance their motivation and confidence. For example, there is little doubt that in Alexander view, his AP ability as a 'gift', and part of the "engine of [his] car", does indeed provide him with a consistent and steady motivational drive, which in turn enhances his self-confidence. The relative rarity of both conditions has led certain participants in this study to perceive their condition(s) as a 'sign' to continue musical studies. In four cases, this led to career changes, after initially pursuing studies in areas other than music. Furthermore, the utilisation of this perceived 'gift' was reported as being an important factor in the decision to study music at a tertiary level. Hence, to ensure their 'gift' is not wasted requires individual possessors to utilise and maximise its potential, by implementing appropriate developmental strategies, including musical studies at a tertiary level.

5.1.2.3. Autonomous regulation and competence.

The impact of synaesthesia and AP on autonomous regulation and competence is considered in this subsection. Intrinsic motivation is dependent on the experience of both autonomy (the need to be causal agents of one's own life) and competence (the need to feel effective and experience mastery) (Deci & Ryan, 2000; Ryan & Deci, 2017). The first of these needs – autonomy – is highlighted in reports from both synesthetes and AP possessors in this study, regarding childhood occurrences of self-directed music participation, often in the face of initial parental reluctance. The second of these needs is emphasised in an exploration of the potentiality for AP associations to act as a practical aid in music related tasks, thus increasing feelings of competence.

5.1.2.3.1. Self-directed learning.

Name	***Condition(s)***
Benjamin	Synaesthesia and AP
Chloe	Synaesthesia and QAP
Ava	AP
Oliver	QAP

The self-directed desire to commence music lessons at a young age was reported by both Ava and Benjamin, who actively campaigned to begin musical training as very young children. Indeed, both Ava and Benjamin received their initial musical training from their mothers, who were both piano teachers. Interestingly, their insistence that their initial desires to learn were self-driven. Ava, for example, indicated "it is very easy to assume tiger mum status when you say, "Oh yeah, I started learning piano when I was two"", noting however she believes her early lessons were "me-driven."

Similarly, Benjamin described his earliest piano lessons with his mother as being instigated by himself:

> BENJAMIN: My mother is a trained primary music specialist. She also teaches music privately, so most of her students are piano students. When I was born (or before I was born) I would hear and see her teaching students. She tells me (because I can't remember this) that when I was one, I started asking her for piano lessons and she refused because she thought that it was me just wanting to copy what she was doing. And that went on for two years and when my brother was born, she relented… I think from what she [laughs] tells me, it was more me instigating the lessons than her. I would say to her every day, "Can we have a lesson? Can we have a lesson?" Sometimes we'd have two or three lessons a day. She'd say to me, "I'm just so tired! I've been talking about music all day!" So it was not really her saying, "Let's have a lesson now!" Or, "You need to go and do your practice." It was me saying, "I want to have a lesson. I want to talk about this. Let's go."

Furthermore, Benjamin described partaking in long hours of self-directed practice on a daily basis, stating “I used to sit down at the piano for three or four hours after school,” which tied in with his earlier comments on the self-directed nature of his initial musical engagement. This intrinsic motivation has remained a constant driving force for Benjamin throughout his studies and fledgling career.

Ava and Benjamin were not alone in describing an early desire to engage with music. As a synesthete, the memory of discovering the piano at the age of four is a

multisensory one for Chloe, and one she admitted had a profound effect on her, ultimately serving as a catalyst for her desire to learn the piano:

> CHLOE: I was four and I discovered the piano, which had never been discovered before me [laughs] … It was at a house three doors or so down from here where my father's first wife and family and extended family were (in Greek style) living. They had a grand piano in the house and I went around to visit and my older sisters, who were seven and nine years older, got me to play the piano with every body part other than my hands. I didn't know any better. They were rolling on the ground, laughing. And I thought, "Oh this is great." The piano: this music thing was this heightened experience. It was full of hilariousness and rolling on the ground and all this physicality: elbows, nose, knees on the piano. And in the background was a pavlova cake that my Greek grandmother had made that I kept walking past and stealing bits from on a table. It was this multi-sensory kind of experience. It had such a profound effect on me that I campaigned for two and a half years before my parents got me a piano and some piano lessons [laughs].

While the multisensory experience Chloe alluded to is not synesthetic in nature, she believes it "helped to reinforce this extra dimension that music had for me," thus becoming part of a broader multisensory experience of music she continues to experience within her life, and which includes genuine synesthetic experiences.

The intrinsic drive to study music detailed by Chloe was also discussed by Oliver, who described his "need to make music" as a child as "central", and the "only thing"

he wanted to do. Oliver indicated having a strong fascination with pitch and pitch memory from a young age, fuelling his desire to learn music, which he described as "self-directed":

> OLIVER: What I describe about my self-directed learning as a child and singing until it was right, that's the only way I can describe it. It was just, "No, it's not ready yet. It doesn't sound right." You have to work it until the voice matches what you want. So that was central.

Oliver depicted this learning as "so self-directed too because often that practice would be completely alone, in my own bedroom at night."

5.1.2.3.2. Practical aid.

Name	***Condition(s)***
Lucas	AP
Sophie	AP
Zoe	AP
Ava	AP

When discussing how the practical benefits of their conditions could potentially increase motivation to pursue a career in music, AP was primarily signalled out as imparting an advantage. As can be observed in the following comments by Lucas, AP enabled him to begin his tertiary education with greater confidence and motivation than he believes he would have had otherwise: "When I got to Uni, I found that perfect pitch was useful in some aspects (when it comes to part of an aural studies examination which accounts for half of it - I had a leg up in that regard) but there were other parts of my musicianship that hadn't yet been consolidated that I needed to

work on. So, if I didn't have perfect pitch as well, I might have gone in with slightly less confidence and general motivation." This increase in confidence as a direct effect of the practical aid provided by AP has led others, such as Sophie, to concede that a different career choice may have been made in the absence of AP possession: "I might not be studying music. I think I might not because I would think that being able to get this far with music - AP would have some part to play in that…I think it could have motivated [me] to persevere in some ways."

As was reported by both Lucas and Sophie, having AP was a substantial motivational factor for Zoe, who indicated both she and her mother wanted her to pursue a career in music because she had "this talent". Without it, Zoe does not believe she would have followed this career trajectory:

> ZOE: Ah [pauses] it was a quite big motivation because when I have AP, I can compose songs and then because I love composing, that's why I wanted to do music…the only reason that my mum wanted me to do music and then me later on was because I had this talent…I like art as well, but I do music better than art…[AP is] probably why I'm more talented in music than other subjects, because all my talent is in music.

Interestingly, Zoe also indicated she was both a visual and performing artist, but that due to her AP she was a "better" and "more talented" musician than visual artist, thus tipping the balance in favour of her decision to follow a career in music.

The possession of AP was demonstrated to be potentially decisive when weighing up future study or career choices. Ava, for example, indicated she had initially envisaged studying economics and law, but viewed her AP possession as a 'validation' of her decision to study music:

> AVA: It validates your choice to do music. You're like, well if my brain works in this musical way, then why would I do anything else? I think that was quite a big part of me deciding to do music at Uni. Most of school I found quite easy but then when I thought about it, it was like, "What actually clicks the easiest? What is my brain geared towards? It's music." I'd say AP probably has quite a bit to do with that… at the end of the decision to do tertiary music I was like, "Hang on, I really, really like this and it's just something that I get. I get it." Even when people are introducing these new concepts and things in terms of harmonic analysis or something and I'd pick it up really easily and people would be like, "Oh you just know it because your mum taught it to you." I would be like, "No, I've never come across this before." I'd just get it.

Ava's decision to study music was in large part motivated by her understanding that her AP enhanced both her musical skills, and enjoyment of music: "What do I do when I'm trying to procrastinate from doing all my maths exams or something? ...I realised it was music. I haven't looked back. [Laughs]." The practical benefits conferred by the possession of AP were therefore reported as enhancing feelings of both confidence and competence for certain music related tasks.

5.1.2.3.3. Key points of autonomous regulation and competence.

These conditions were noted as enhancing feelings of autonomous regulation and competence: experiences on which intrinsic motivation is dependent. Participants reported childhood occurrences of self-directed music participation, independent of parental encouragement. This desire to participate in music related activities was reported as being driven by the possession of either synaesthesia or AP. Furthermore, the potentiality for AP associations to act as practical aids in music related tasks, was described. This practical aid was reported as resulting in the enhancement of feelings of competence.

5.1.3. Summary of Motivation

Synaesthesia and absolute pitch (AP) were frequently reported as playing a role in energising and directing participants' motivation to study music. This was particularly salient at a tertiary level. Indeed the impact of synaesthesia and AP possession on the participants' motivation to *begin* formal musical training was weak, in contrast to the impact of these two conditions on the participants' motivation to *continue* formal musical training at a tertiary level which was strong, with 62.9% of participants (n=22) reporting an effect.

This motivational drive was reported as being influenced by three intersecting intrinsic motivational forces. First, synaesthesia and AP were reported as potentially providing a deeper relationship with music, by enhancing the enjoyment of music, adding an extra dimension to musical practice and consumption, as well as offering a stronger connection and engagement with music. Second, synaesthesia and AP were found to provide purpose and – in some cases – spiritual or religious validation for a career choice in music. A review of participants' beliefs that their condition(s) are a

'sign' or a 'gift' uncovered four cases where career changes back to music were motivated by the belief in this 'gift'. It was also noted that participants' desires to not 'waste' their conditions led them to choose study and career directions that would allow them to optimally use and develop their musical abilities. Finally, feelings of autonomy and enhanced competence were noteworthy. Autonomous regulation was stated as occurring during childhood, with examples of self-directed music participation at a young age provided. Furthermore, the possession of AP, and in particular the practical benefits for certain music related tasks it confers, were noted as enhancing feelings of both confidence and competence. Together, these three aspects of intrinsic motivation can potentially operate in isolation or simultaneously, to impact the direction and strength of synesthetes' and AP possessors' motivation to pursue studies in music.

One further motivational aspect that was reported as influencing participants' choices of area of study or career was the development of a positive musical identity. In the following section, the impact of synaesthesia and AP on identity formation is examined.

5.2. Identity

"It has created a musical identity for myself: having AP."

Cooper (AP)

The role of synaesthesia and absolute pitch (AP) on participants' identity formation is examined in this section. The formation and stability of identity is contingent on both

the context within which it evolves, and a sense of self-consistency across time (Erikson, 1980). From a musical context, identity has typically been considered in terms of music preferences (Dys, Schellenberg, & McLean, 2017). Questions remain, however, concerning the extent to which unique experiential factors may play a role in the formation of identity. For the purposes of this study, the impact of possessing synaesthesia or AP on the formation of identity, and the importance of participants' personal insights into their condition(s) on this process, are assessed.

To examine the impact of these two conditions on identity formation, the analyses which follow are subdivided into three parts. First, participants' beliefs in their condition(s) as special, or a defining characteristic of their musical identities, are explored. This includes an investigation of within-group differentiation among synesthetes or AP possessors. Second, reports of increased popularity and pride as a direct result of their condition(s) are provided. Third, feelings of fear or trepidation at the thought of the potential loss of their condition(s), acknowledged by participants in this study, are presented. These feelings are examined as indicators of the importance of synaesthesia and AP in maintaining a consistent musical identity over time.

5.2.1. Synaesthesia and Absolute Pitch as a Special or Defining Characteristic

Name	***Condition(s)***
James	Synaesthesia and AP
Chloe	Synaesthesia and QAP
Mia	Synaesthesia and QAP
Jack	Synaesthesia
Lily	Synaesthesia
Liam	AP
Cooper	AP
William	AP
Sophie	AP
Oliver	QAP

The integration of synaesthesia or AP into a possessor's musical identity was reported as being enabled by the perception of their condition(s) as 'special', or as a 'defining characteristic'.

Synaesthesia was recurrently reported as being a defining characteristic of the musical identities of synesthetes. Chloe, for example described the deep intimacy and special bond she experiences with music as being due to her synaesthesia: a "core that is inviolable and very special and nice". She described her synaesthesia as her "biggest spiritual source", which more broadly fulfils a "restorative function" in her life; when negative situations occur, she is able to tap into this "basic fundamental positivity and joy source", enabling her to find personal justification and validation, without having to seek it from external sources. When asked to describe the 'best thing' about having synaesthesia, Chloe responded:

> CHLOE: The heightened juice and the deeper intimacy I feel with music because I know that the colours that I'm seeing are not real...So it feels like I've got something special for me. That can buoy me up even if I'm having a shitful rotten time with my music profession. Even if I'm feeling that it's full of bastards and they're all out to get me and no one appreciates anything I do or whatever. After that clears, and it's very rare that I feel that, what reinstates itself is that feeling that [synaesthesia] is part of a core that is inviolable and very special and nice.

Synaesthesia is thus part of the ‘inviolable core’ of her musical identity, with which she has a profound and intimate relationship: testament to the emotional impact synaesthesia can bestow.

In a similar way to synaesthesia, AP was frequently reported as being a central and inseparable part of a possessor’s identity as a musician. Liam, for example, indicated his AP ability is related to his sense of self and is “one of the few things about myself that I know intrinsically”. This characteristic is mirrored in the reports of both Oliver and Cooper; Oliver stated that he is unable to imagine his musical identity as separate from his AP ability: “It's unthinkable to imagine how it would not be part of it. How can you separate out something that fundamentally informs what you do? Knowing what the notes are tells me what to play. I can't imagine what it would be like to be any other way.” Similarly, Cooper indicated: “it's created a musical identity for myself: having AP. I think that has affected it.” The reports of Liam, Oliver, and Cooper, all revealed that their AP ability is therefore inextricably linked to their musical identities.

Synesthetes and AP possessors furthermore reported identifying with their condition(s) due to their perception of them as ‘special’ or ‘unique’. James, for example, noted it was when “I started to realise that I had the ability of perfect pitch that I realised, "Wow, I'm getting things that not a lot of other people can." So, I started experimenting in different ways, different pieces and different ideas. It really quenched my hunger for understanding music as interpreted through perfect pitch.” A more precise example was offered by William: he recalled one aural test where he was able to complete a tone row identification task on the first attempt, when the

recommended number of repetitions was eight. His ability to complete the task with such facility made him feel “pretty special”. Moreover, the differentiating characteristic of AP, described by both James and William, was echoed by Jack in relation to his synaesthesia:

> JACK: I just reckon there's something about it that makes my brain work in a different way to anyone else and so I suppose that makes me slightly different. Hopefully, in terms of composition, it allows me to write music that's slightly different to anyone else. ... I suppose maybe it informs - at least on a subconscious level - my approach: what I choose or what I like to hear and therefore what I create.

Jack attributed the unique workings of his brain to his synaesthesia, which subconsciously informs his compositional approach and musical choices. As a composer, this ‘unique’ outlook is translated into a ‘unique’ compositional voice and is therefore central to his identity as a composer.

The manifestation of this distinctiveness was often mediated by teachers. Lily’s synaesthesia, for example, was discussed during aural class, with Lily noting that being singled out in this way made her feel “a bit special”. Lily indicated her synaesthesia had become an essential aspect of her identity at the Conservatorium, where having synaesthesia had given her “a bit of credibility”. Synesthetes and AP possessors also reported actively seeking out this distinction themselves. William, for example, indicated he would prefer to learn from a teacher who does not have AP, as having “something over someone else, especially if it’s a teacher”, makes him feel

"even more special". The same applies to small group ensembles, where again he stated he would "like to be the only one to have that ability" and noted this makes him feel special and unique.

5.2.1.1. Within-group differentiation.

Name	***Condition(s)***
Xavier	Synaesthesia and AP
James	Synaesthesia and AP
Benjamin	Synaesthesia and AP
Alexander	AP

A feeling of distinctiveness can positively influence the assimilation of a specific identity, such as the identity of 'synesthete' or 'AP possessor'. Differentiation, however, can also be expressed within this same group identity. As noted by Xavier, "It was pretty nice to have some little quirk about myself that was different…I grew up and only when I was 15, I found out that not everyone has AP. Also, I found out that I'd been associating it with colours. I'd met a few other people with perfect pitch. They said they just knew it or it just clicks with them. And I'm like, "You don't see a colour?" and they're like, "No." So that makes it even more different. It's very [laughs] cool." Within the already differentiated group of AP-possessors, with whom Xavier identified, he was also able to further differentiate his identity from others within that group, by virtue of his additional associative synesthetic percepts. This within-group demarcation was comparably underscored by James, who provided an example of both a sense of belonging and distinction as an AP-possessor. James described his AP as enabling him to be 'admitted' into an 'exclusive club', only for AP possessors. He described, however, the difference between his AP ability, and that of two of his close friends – Alexander and Mason (both of whom are participants in this study):

> JAMES: It is nice to have somebody who - instead of saying, "Oh, you have perfect pitch - lucky you!" they say, "Oh you have perfect pitch - so do I!"…I have one friend named Alexander. He's a first-year pianist. He's one of the most brilliant pianists I've ever heard. Not only has he developed the ability to sight read quite well, I've seen him - for fun - sit down in the basement and play pieces and transpose them from minor to major. I just sit there laughing because it's one of the most amazing things. You know when you see something so amazing that you just laugh? It's freaky to see that: how he can do this without even flinching! He doesn't even have to think. He's just, "Oh, that's fine." Another friend of mine, Mason, it becomes very easy for him to learn his pieces as well. He is particularly good at sight-reading. The difference between Mason and I is that he's much better at sight-reading. My sight-reading ability is still good but my perfect pitch is better once I've memorised a piece because that pitch will never go away for me. So that's the difference between myself, Mason and Alexander.

James described ‘belonging’ to the same group as his two friends with excitement: friends he portrayed as being extraordinarily talented. His AP ability thus enables him to identify as a member of a group he perceives as being distinctive, while he is also cognisant of each individual member’s unique AP-enhanced abilities. Both the ‘group’ and ‘within-group’ distinctiveness is thus positively perceived.

In contrast, Benjamin noted that one of the most difficult aspects of his AP is the lack of understanding from others, of his unique experience of music. He described his

frustration with other people who believe they have AP, but don't – "and I can tell they don't" – yet his frustration appears to stem not from the fact that they may or may not have a robust note-labelling ability, but rather that they do not have the same engagement with keys that he does:

> BENJAMIN: Another thing that I would say is equally bad is that a lot of people that I know say, "Oh, I have perfect pitch" and they don't, and I can tell they don't. Firstly, they can't name the notes as they say they can, but also they don't have - as I keep returning to – this engagement with keys and this engagement with sounds, very individual, strong, personal feeling. People who have true AP who have that are in the minority in terms of general musicians, and people don't know what it's like. People just think that you're a bit of a freak for finding it offensive that something's in the wrong key or think that it's just a nice party trick that you can name that note when they don't really understand how profoundly it impacts on everything - a bit like autism, really. That's hard: not having other people to share those experiences with.

Benjamin states this lack of understanding is similar to what he experiences with his autism, furthermore describing how difficult he finds it to not have other people to share these experiences with. He employed the word "freak" to describe how he imagines others view his sensitivity to pitch, thus highlighting the dichotomy that exists between his strong attachment to his AP, and the loneliness and misunderstanding it can engender.

It is noteworthy that, like Benjamin, Alexander also instinctively differentiated his way of viewing his AP with that of his AP-possessing peers, stating: “So I have this constant thinking that having perfect pitch is quite important and quite special, whereas some of my friends who have perfect pitch wouldn't really think like that. I think I'm a little bit different.” Contrary to Benjamin, however, this difference appeared to be positively perceived by Alexander.

5.2.2. Increased Popularity and Pride

Name	***Condition(s)***
Mia	Synaesthesia and QAP
Sophie	AP
William	AP
Alexander	AP
Liam	AP

The possession of synaesthesia or AP was stated as potentially increasing the popularity of possessors, and by consequence heightening feelings of pride. Mia, for example, discussed the ‘star’ factor having synaesthesia and QAP has afforded her within her friendship group: “My close friend who's doing neuro[logy], he doesn't have either [synaesthesia or AP], and it's like, "I want your brain!" to see how it works.” This positive differentiation within a friendship group was also noted by Sophie, who indicated the best thing about having AP was her ability to “impress” people.

William similarly indicated feeling a heightened sense of pride due to his AP, which enabled him to “become a lot more popular with people”, specifically after being bullied at school:

> WILLIAM: Well, having AP has been a real help for me because it allowed me to become a lot more popular with people. I'll just say this briefly: I haven't had the best childhood ever. I was bullied a lot at school and that is partly where my confidence has dropped. Music's always been an escape for me - away from all of that. In my head, I've always had something that's sort of going on. I can hear all these things that no one else can. I started to think, especially getting to the age of 12, that this is something really, really special. This is something that has been given to you; you need to pursue it. Getting that popularity at my new school really helped me establish myself and establish what I needed to be doing and this is what I need to be doing.

Music was therefore an escape for him: his AP enabling him to reclaim his lost confidence. This heightened popularity persisted after leaving high school; William was asked whether he had ever experienced a highly positive reaction to his AP, to which he responded:

> WILLIAM: Yeah [laughs], really, really, really positive. I was very, very popular at my school in the music area because I had this ability. I went back recently to organise a concert that I'm doing on Wednesday. I walked into the Year 11 classroom and the first thing that one of them says is: "Is this the guy with perfect pitch?" [Laughs] The teacher said, "What's this note? Laaaah!" I said, "It's an E-flat!" I'm still remembered there, which is good.

This popularity, instigated by his AP ability, not only aided William to establish himself in his new school, but also conclusively determined his future career

direction, by accentuating what he "needed to be doing". He furthermore indicated: "It makes me feel better about myself that this is what I need to be doing because this is a rare gift in Australia. It's something that I need to continue with." The popularity he felt, due to his AP, thus enabled him to integrate his AP into his musical identity and pursue a career in music with confidence.

The increase in popularity noted by William was similarly depicted by Alexander, who described a seminal AP experience during his high school years involving a school-organised fundraiser, designed to incorporate Alexander's AP ability. Alexander was challenged to play any song chosen by his comrades, earning $1 for every song he could successfully play. He was by all accounts 'successful', playing back 65 songs, and donating $65 to charity. Having himself, and his unique skill, put under the spotlight in such a positive way is an experience he admitted he will "always remember". He explained being "popular" at school due to both his AP, and to his ability to play back any previously unheard piece after a single hearing: "I was popular because people knew me as a pianist who could listen to a song that I wouldn't have previously known and had never heard before, but then immediately after that, I would come to the piano and play it back to you, having the chords in the right key and the right melody". Alexander furthermore acknowledged his peers were "surprised" by his ability and noted: "They actually announced me at school. Everyone was talking about it." When asked how this made him feel, he replied "To be honest, it made me feel special…I was really proud of myself and I wanted to be modest about it; I didn't want to show off." Having a unique skill singled out by both his teachers and peer group during adolescence was demonstrably confidence enhancing for Alexander. This elevation of his social status within his school

environment was also evident during a second occasion communicated by Alexander, where during a discussion of 'savants' in his Year 11 Psychology class, it was suggested that Alexander might be a music savant. Although it was ultimately decided Alexander did not meet the requirements (which included cognitive deficits), the mere fact that his skills were discussed in this manner was a considerable bolster for Alexander's confidence.

Liam similarly reported experiencing intensified feelings of pride due to his AP possession. Discussing the "level of pride" felt by both himself and his younger brother (also an AP possessor), Liam stated:

> LIAM: We used to enjoy showing off, boasting and playing games of picking the note and impressing the other two or three people in the class. Other people were impressed by it and we weren't ever shy of showing it off…There's a certain satisfaction and thankfulness for having it. I guess there is a certain level of pride. You feel that you can do something that other people can't do, most people, so that's a positive.

For Liam, his AP is "just so much a part of me", that he is "very happy and glad" to have it. He ascribed this feeling to the fact that he can do something that "other people can't do." Not only did Liam mention his AP has enhanced his sense of pride, but he suggested it also aided in the development of his musicality: "It's certainly given me great advantages…that's given me confidence and maybe aided the development of musicality over the years." Indeed, musical identities mediate musical development, and in the all of the cases noted above, it is the participant's synaesthesia or AP that

was reported as enhancing of their popularity and sense of pride. This enhancement directly aided their musical development and helped sustain their motivation to pursue a career in music.

5.2.3. Fear of the Loss of Synaesthesia or Absolute Pitch

Name	***Condition(s)***
Benjamin	Synaesthesia and AP
Chloe	Synaesthesia and QAP
Lachlan	AP
Liam	AP
William	AP
Max	AP
Alexander	AP

The fear derived from the potential loss of their condition was one of the strongest indicators of the importance of synaesthesia and AP within the construct of participants' identities. Indeed, 14 of the 35 participants (40%) explicitly indicated fearing the loss of their condition.

When describing her attachment to her synesthetic percepts, Chloe mentioning that the mere thought of losing them was making her "anxious", and her "heart go faster". She views her synesthetic percepts as the inner manifestation of what she described as both the "juice" and "joy" of life, which come "from one's own inner make up." In a similar manner, Lachlan noted the loss of his AP ability would engender the feeling that a part of him would be gone: "I'd be pretty upset…I'd feel a lot more lost. I'd feel like a part of me would be gone if I didn't have pitch recognition skills…if I didn't have it, I wouldn't have the same sort of inner voice…If I didn't have it, I probably wouldn't be the same person." This possible loss of identity was comparably noted by Liam, who made the analogy that losing his AP would be "as weird as turning around

and not having a left hand or something like that". Liam furthermore acknowledged he was unable to "even begin to imagine" not having AP, noting this would be an "alien" way of listening to music.

The potential age-related loss of AP was a subject that was broached by participants in this study. William affirmed he is cognisant of this possibility, stating: "I'm always conscious of whether this ability is going to fade away, eventually. I'm thinking, "Is it going to happen?"" This potential loss "terrifies" him and he acknowledged it would feel like he had "lost" himself, as his AP is "something that defines who I am as a person…it's something special about me that's different to everyone else." Max analogously indicated he would be "lost…entirely lost" without AP but did volunteer that he perceives his pitch perception is becoming more malleable with age. Now in his 40s, Max is noticing he is able to 'trick' himself in his pitch perception abilities, and while this brings with it a certain flexibility he had previously lacked in certain situations, he admitted that on occasion he has tricked himself to the point of losing his sense of pitch centre. The possibility that he may lose his AP, or that it may weaken, scares him.

The prospect of an age-related loss of AP generated such a degree of concern for Alexander, that he tests his AP first thing every single morning, to ensure it is still there:

> ALEXANDER: So if I - for whatever reason, for unfortunate reasons - suddenly lose it, it would be a big loss. I always try, every morning, to play the piano and always ask myself, "Is my perfect pitch alright today? Yes it is." I

have that feeling sometimes. I have this feeling that I don't want to lose it. … I was told once that as you grow older, there's a chance of losing it. So after I was told by that person, I was a little bit worried. I started to feel, "Ooh, I don't want that." So every morning, whenever I start practising a piece, I say, "Oh, that's in F sharp major. Good - it's still there."

Alexander's morning ritual involves a certain level of veiled anxiety. He mentioned one instance several years ago when, waking early and extremely tired, he momentarily felt that he had indeed lost his ability: "I don't know where it went, or what happened to it, but it was quite stressful." This shocked him, and although his AP reappeared not long afterwards, the implications of this incident have obviously remained a lasting concern.

The emotional magnitude of this concern was exemplified to no greater degree than in conversation with Benjamin, when - voice cracking - he described the potential loss of his AP as a "death":

BENJAMIN: [Pauses] It's hard for me to conceive of because I don't know what it's like not to have it, but I think it would feel like a death. That sounds a bit melodramatic, I know, but it would feel like I couldn't access music in the same way. It would just be a big mess. It would be like being colour-blind, really. Even now, just thinking about it, I'm getting a bit upset because it's so awful. [Pauses] It's so awful just to think about.

At this moment during the interview the subject was gently changed, in order to alleviate the growing anxiety exhibited by Benjamin. The loss of his synaesthesia and AP was a potentiality that scared Benjamin, as he specified it would adversely affect his deep relationship with music and engender the loss of a substantial component of his musical identity.

5.2.4. Summary of Identity

The above analyses confirm that the possession of synaesthesia or AP was seen by the participants as influencing the development of a positive musical identity. Possessing one or both conditions was also reported as producing a sense of differentiation between musicians, while enhancing feelings of distinctiveness. Through an analysis of the data obtained during the interviews, synaesthesia and AP were identified as influencing three aspects of the process of identity formation.

Importantly, synesthetes and AP possessors noted that they perceived their condition(s) as being 'special', and thus integrated them as a 'defining characteristic' of their musical identities. This allowed possessors to contextualise their identity in terms of belonging to a select group ('synesthetes' or 'AP possessors'). Within-group differentiation, however, was also reported as occurring, with possessors identifying differences between individual possessors in these select groups. Differentiation within these groups was in general positively perceived, however examples of observed misunderstanding and judgement were also reported. In addition, participants stated an increase in popularity due to the possession of their condition(s), specifically during the formative years of adolescence. This heightened popularity increased feelings of pride and was positively integrated into participants' musical

identities. In particular, the fear of losing their condition(s) was explicitly acknowledged by 40% of participants (n=14). Statements from participants regarding the potential loss of their condition(s) highlighted the importance and centrality of synaesthesia and AP within their musical identities. In particular, these statements underscore the fundamental role of synaesthesia and AP in providing consistency to possessors' musical identities across time.

5.3. Summary of Affect

Statements from participants in this study revealed that one of the greatest influences of their synaesthesia or AP is the potentiality for these conditions to promote the deep engagement and strong relationship with music they report. The data collected demonstrated that both synaesthesia and AP enhance participants' connection with, and attachment to, music. Two interrelated affective domains – motivation and identity – were reported as being enriched by the possession and unique experiential aspects of synaesthesia and AP (see Figure 5.3).

The possession of synaesthesia or AP was reported to especially energise and direct participants' intrinsic motivation to study music. These conditions were described as enhancing the enjoyment of music, and in particular adding an extra dimension to musical experiences. The belief these conditions are a 'sign' or 'gift – either spiritually or religiously – augmented participants' sense of purpose in undertaking studies in music. Indeed, this sense of purpose, directly linked to their condition(s), would lead four participants to return to a career in music. The belief in this gift was similarly felt by other participants to be 'too good to waste', and thus the decision to study music was facilitated by the belief they were fulfilling a predetermined, or

optimal, career path. The desire to engage with music, fuelled in part by the unique experiential aspects of their conditions, was conveyed in examples of self-directed music participation at a young age. These examples attest to the enhancement of autonomous regulation afforded by their condition(s). Furthermore, practical benefits on certain musical tasks, directly aided by AP, were reported to enhance both confidence in these tasks, and an overall feeling of competence (Figure 5.3). Motivational drive was therefore positively affected by the interaction of these different facets. This interaction, however, varied in strength and combination between participants.

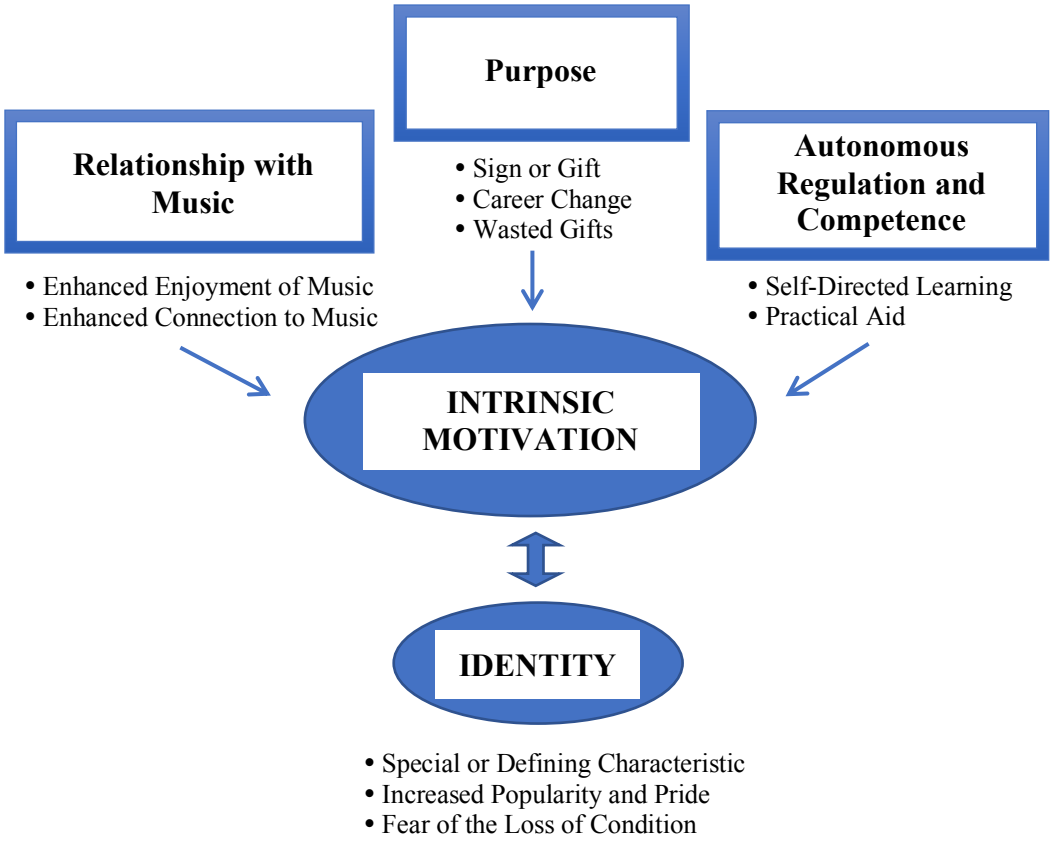

Figure 5.3. The impact of synaesthesia and AP on intrinsic motivation and identity formation.

A positive musical identity was similarly reported as being influenced by the possession of synaesthesia or AP. This was in large part due to the sense of differentiation afforded by the possession of one or both of these unique conditions,

which were frequently stated as being special, or indeed a defining characteristic of the musical identities of the musicians interviewed in this study. Participants also provided examples of feeling distinct within these condition-specific groups. While these feeling were generally positive and inclusive, negative judgemental aspects were also reported. Participants frequently acknowledged feeling a heightened sense of pride, due in large part to the increase in popularity the enjoyed, because of their condition(s). Examples given were commonly of adolescent experiences, and thus were central to shaping their developing musical identities. Finally, participants frequently declared being afraid of one day losing their condition(s), highlighted the importance of synaesthesia and AP as core aspects of their musical identities (Figure 5.3).

Individual differences in the strength and degree to which synaesthesia or AP impact participants' motivational drive, identity enhancement, and emotional attachment to their condition(s) were reported. These differences interact with varying social influences and beliefs to impact the strength and outcomes of study and career decisions. Ultimately, however, the emotional connection to their condition(s) is an important element in the musical identities of the musicians interviewed. To the final interview question: "If you had the choice to have or not have synaesthesia and/or AP, what would you choose?" all 35 participants (100% of total participant group) affirmed they would choose to keep their condition(s).

The previous results chapter (Chapter 4: 'Cognition'), and this current chapter, focused on how the possession of synaesthesia or AP influences cognitive and affect aspects of musical development. The internal forces outlined in these two results

chapters influence musical behaviour, and therefore in the following results chapter (Chapter 6: ‘Behaviour’), the behavioural outcomes of the possession of synaesthesia or AP on musical development are reported and analysed.

Chapter 6

Behaviour

In this chapter, the impact of synaesthesia and absolute pitch (AP) on the external musical manifestations, or behaviours, of the cognitive and affective inner processes of musician synesthetes and AP possessors is examined. It outlines how musical behaviours are influenced by the possession of synaesthesia or AP by using self-report measures, defined as self-behaviours that are identified through a participant's own observations and reports (Gerrig & Zimbardo, 2002).

The chapter commences with an analysis of the descriptive statistics obtained during the interview process by outlining the musical tasks that were reported as being either facilitated or hindered by the possession of synaesthesia or AP. Following this analysis, the ensuing two chapter sections outline the specific behavioural outcomes reported in this study.

Two categories of behavioural outcomes are reviewed: musical choices and preferences, and music performance. First, the impact of synaesthesia and AP on musical choices and preferences is assessed, including choice of repertoire or music listening, preference for specific musical styles, compositional choices, and choice of instrument or instrumentation. Second, a discussion on musical performance considers the effects of synaesthesia and AP possession on musical interpretation,

technique, and transposition, including playing a transposing instrument, and performance at baroque or classical pitch.

Musical tasks can be identified as being either aided or hindered by the synesthetic or AP experience, while the resultant behaviours can be broadly classified into two categories: engagement behaviours and avoidance behaviours. Where applicable, examples of engagement and avoidance behaviours are given for each of the categories noted above.

6.1. Descriptive Statistics of Facilitated and Hindered Tasks

During the interview, participants were specifically asked if any musical tasks were made easier (facilitated tasks) or made harder (hindered tasks) by their synaesthesia or AP. Participants were free to report any tasks they believed were affected by their condition(s), while also providing details surrounding how, and to what extent, these effects occurred. The results of these two questions were tabulated, with a thematic analysis of the responses enabling them to be grouped into categories, as outlined in Tables 6.1 and 6.2. In Table 6.1, the number of participants who responded that at least one music-related task was facilitated by their condition(s) is recorded in the column that reads ‘Tasks Easier’. The thematic categorisation of the responses is organised under six sections: aural skills, creative practices, memory, auditory imagery, self-esteem, and emotional expression.

Table 6.1
Participant responses to the question as to whether their synaesthesia and/or AP facilitated specific music related tasks

	Tasks Easier	Aural Skills	Creative Practices	*Memory*	*Auditory Imagery*	*Self-Esteem*	*Emotion*
Synaesthesia (n=7)	**7**	4	4	*7*	*2*	*0*	*3*
AP (n=17)	**17**	17	4	*16*	*6*	*4*	*1*
Both (n=11)	**11**	9	5	*11*	*9*	*2*	*1*

As documented in Table 6.1, all 35 participants indicated that their synaesthesia or AP was beneficial to at least one music-related task ('Tasks Easier'). The influence of synaesthesia and AP on specific cognitive and affective aspects of musical engagement - covering the final four sections of the table - has previously been described (see Chapters 4 and 5: 'Cognition' and 'Affect'). Two of the categories in Table 6.1, however, fall within our discussion of the behavioural aspects of musical development: aural skills and creative practices. Thus, for the purposes of this chapter, the first two sections are examined in more detail. Within the 'Aural Skills' category, tasks facilitated by synaesthesia or AP include melodic transcription and dictation, sight-singing, sight-reading, identification of tone rows, accompanying, tuning, and intonation. Within the 'Creative Practices' category, music arrangement, composition, and improvisation are designated as being enhanced by the participant's condition(s).

The tasks detailed above were reported as enhanced by either synesthetic or AP associations. Certain tasks were also noted as being hindered by these conditions, and these are tabulated in Table 6.2. The number of participants who responded that at least one music-related task was hindered by their condition(s) is recorded in the column that reads 'Tasks Harder'. The thematic categorisation of the responses is organised under four sections: mismatch, restrictive, reliance, and distracting.

Table 6.2
Participants were questioned as to whether their synaesthesia and/or AP hindered specific music related tasks

	Tasks Harder	Mismatch	Restrictive	*Reliance*	*Distracting*
Synaesthesia (n=7)	**3**	0	2	1	2
AP (n=17)	**14**	13	14	0	1
Both (n=11)	**9**	7	6	2	3

Twenty-six participants (74.3% of total number of participants) indicated their condition was a hindrance to at least one specific musical task, with both synaesthesia and AP represented. Thus, for nine participants (25.7% of total number of participants), no adverse effects on music related tasks were reported.

For the twenty-six participants who did indicate their condition adversely influenced specific musical tasks, these tasks can be divided into four categories (see Table 6.2). The first two of these categories – 'Mismatch' and 'Restrictive' – are relevant to our discussion on the behavioural aspects of musical development, and are thus examined in more detail. The 'Mismatch' category refers to contradictions and incongruences between synesthetic or AP associations and certain musical tasks; these include transposition, a capella singing, and changes in intonation or pitch systems. The 'Restrictive' category refers to the limiting nature of synaesthesia or AP on technical and performance aspects of the possessor's musical abilities.

As can be seen from a comparison of the data in Tables 6.1 and 6.2 above, there are a substantially greater overall number of facilitated than hindered tasks. The addition of the number of facilitated tasks totals 105, while the number of hindered tasks totals 51. The mean number of facilitated tasks per participant is therefore 3, in comparison

to a mean score of 1.46 hindered tasks per participant. There are therefore more than twice as many tasks that are reported as being facilitated by participants' conditions.

These figures can be categorised by condition. As shown in Table 6.3, all groups reported a substantially higher number of tasks that had been facilitated, rather than hindered, by their conditions.

Table 6.3
A comparison of the total number of tasks reported as either being facilitated or hindered by synaesthesia or AP

	Total no. Facilitated Tasks	**Total no. Hindered Tasks**	**Ratio**
Synaesthesia (n=7)	20 (*M* = 2.86)	5 (*M* = 0.71)	4:1
AP (n=17)	48 (*M* = 2.82)	28 (*M* = 1.65)	1.7:1
Both Conditions (n=11)	37 (*M* = 3.36)	18 (*M* = 1.64)	2:1

Note. Means have been adjusted to incorporate all participants, including those who reported their condition(s) induced no negative effects, as part of the mean score average. Ratios have been rounded to one decimal place.

It is noteworthy that the ratio of facilitated to hindered tasks in synaesthesia is double that exhibited by both AP possessors and those with both conditions. A comparison of the mean scores reveals this difference is due to the substantially lower 'hindered tasks' score of synesthetes. The number of reported difficulties to complete musical tasks was therefore greater in AP possessors.

Overall, there were fewer participants who noted their conditions were a hindrance to specific music-related tasks (see Tables 6.1 and Table 6.2), and there were also fewer tasks reported as being hindered by either or both conditions (see Table 6.3).

In the following sections, both engagement and avoidance behaviours instigated by synesthetic and AP associations are discussed in relation to the choices and preferences, and performance aspects, of specific musical abilities.

6.2. Preferences and Choices

> "It definitely affects my choice. I don't enjoy classical music (as in the classical era) because it's so single-coloured…So I think that's also why I love jazz, because there are so many different chords and notes. It's very colourful in my head."
>
> *Xavier (Synaesthesia and AP)*

This section assesses the role of synaesthesia and AP on musical choices and preferences. Three areas of enquiry are examined: the impact of these two conditions on musical style preferences and repertoire choices, including concert programming choices and music listening preferences and aversions; the impact of both conditions on the compositional choices of synesthetes and AP possessors; and the potential influence of instrument→colour synaesthesia on the preference for, or avoidance of, specific instruments by synesthetes with this form of synaesthesia.

6.2.1. Stylistic Preferences and Repertoire Choices

Name	***Condition(s)***
Xavier	Synaesthesia and AP
Mason	Synaesthesia and AP
Benjamin	Synaesthesia and AP
Charlotte	Synaesthesia
Thomas	Synaesthesia
Ruby	Synaesthesia
Max	AP

Synesthetic percepts and AP associations were reported as strongly influencing musical style preferences and repertoire decisions. These were noted by synesthetes as being made based explicitly on the synesthetic colour percepts – or lack thereof – a particular piece or style induced, as well as by AP possessors based on the specific characteristic or mood of individual tonalities.

From the perspective of synaesthesia, Charlotte indicated her synesthetic percepts "tend to direct me. I will be drawn to something more if I had that reaction that was a nice colour or a nice picture. I don't feel like I can control that as much. I definitely wouldn't feel as warm towards something if the image I was getting was different." Her preference for playing avant-garde music appears to be largely due to her enjoyment of the "huge bursts of colour" it provokes, with Charlotte noting, "I've just always been drawn to that and I can see much brighter colours for each section of that. I also feel like I can express it better". For Charlotte, avant-garde music induces "stronger" colours than those induced by other forms of music: "I don't actually like that much typical classical Mozart type stuff to play myself…I don't see much. I feel like I don't see much from it. It's very "flat" is how I'd describe it. There's not a lot I would get from it." This divide between classical and modern music, resultant from qualitative differences in the saturation of concurrent colour percepts, was also noted by Xavier. Like Charlotte, Xavier's comparable preference for multi-coloured synesthetic percepts fundamentally affects his repertoire and listening choices:

> XAVIER: It definitely affects my choice. I don't enjoy classical music (as in the classical era) because it's so single-coloured. It's very mechanical: here's

> this and the next colour's this in twenty minutes. It's on the same thing but very technical, whereas I really enjoy twentieth century modern music. I love impressionism because it's very progressive, very colourful in the choices of chords, notes, melodies, even within the orchestration. So I think that's also why I love jazz, because there are so many different chords and notes. It's very colourful in my head. I wouldn't be as engaged in an electronic dance song because it's very singular in colour, unless it was very progressive and there was more musicality to it where I can enjoy the colour and the beat. I definitely think it's impacted my choice of music. I still enjoy baroque music even though it's still pretty singular as well. I think that the colours and that are still quite defined and that's also helped me enjoy that music more.

Both Charlotte and Xavier indicated a relative dislike for classical music, based on the resulting flatness of induced synesthetic colours, with Xavier noting a comparative preference for jazz. This is in contrast to comments made by Thomas, who stated that he does not like jazz music, as "it doesn't have a nice colour…It's quite a lot darker than other music and I think that's based off the sound of the drums and the low string bass. But then it's like juxtaposed with this bright trumpet sound and I don't like it." Thomas made a similarly strong pronouncement in relation to non-western music, which he indicated is all the same browny yellow colour: "it really got to me that it was just all the same colour. It didn't matter what I did. I couldn't discern a different thing. It was all just the same. Really annoying!"

Synesthetic percepts can enhance the enjoyment of particular musical styles, and lead to stronger engagement with these styles. Ruby appeared surprised when asked whether her synaesthesia influenced her stylistic preferences, stating:

> RUBY: [Laughs] Yes, yes, yes [laughs]! That's really funny! Yeah, I think it has. I love early music. Yes, that's [laughs] strange. I love Bach and Monteverdi and people like that and their colours are definitely very rich. There are lots of pinks, reds, yellows and beautiful greens in there. It's very rich and full of jewels, whereas I think a lot of the time I really dislike Bel Canto opera. I find it a lot blander a lot of the time. So yes, I think that's true. I probably would choose things that I think have much more vivid colours. That's interesting [laughs].

Ruby noted a preference for performing baroque and early music repertoire over Bel Canto opera, centred on the former's richness of colour, as opposed to the blandness of the latter. This preference for a richer colour palette was a driving factor in Ruby's decision to specialise as an early music singer.

Stylistic preferences can be the result of the interaction of preferences for both specific synesthetic percepts and tonalities. Mason, for example, indicated he prefers music from the nineteenth century, "just because it has that ability to explore and take you somewhere. Also, the changing tonality aspect - more intricate relationships than simple classical…Just the differences, the synaesthesia responds to them." The satisfaction Mason experiences in following "intricate" tonal relationships – reliant on his AP ability – is enhanced by his resultant synesthetic percepts which "respond" to

these shifts in tonality. His stylistic preferences are thus contingent on the collaboration of both conditions, which increase the pleasure he experiences when engaging with music in certain styles.

From an AP perspective, repertoire choices are also made by AP possessors based specifically on the tonality of individual pieces, and thus on the ensuing "mood" experienced. As stated by Benjamin, "I will admit, if I open up a book of etudes and I see an etude in G sharp minor, I will think, "God, I *hate* G sharp minor" [interviewee's emphasis]…I don't like the key. I don't like how it feels: it's spiky and awkward…If you give me a book of Mozart or Beethoven trios or something and said, "Pick one", I might be more drawn to picking the one in B flat major because I love B flat major." As is the case for Benjamin, AP also plays a vital role in Max's repertoire and music listening decisions. By his own admission, he will "choose not to hear" and "choose not to play" works that are in different keys to the original, qualifying this as "terrible".

6.2.1.1. Concert programming choices.

Name	***Condition(s)***
Benjamin	Synaesthesia and AP
Ethan	Synaesthesia
Max	AP

The preference to play specific pieces or musical styles, based on tonality preferences or subsequent synesthetic perceptual experiences, was noted as being translated into concert programming decisions. Ethan, for example, chooses and orders concert repertoire based on the interaction of the resulting synesthetic colours:

> ETHAN: I tend to choose repertoire that's going to interest me in the way of colour and it's also going to balance itself out in a program together. So I'm not going to choose a whole lot of pieces in E major because it's going to be all these pieces in this same colour...For example, the pieces I'm doing this semester - one of them is in F sharp minor, one's in E major, one's in F minor and one's in D major. Together they create a really nice colour for me.

It is therefore the interest and balance of synesthetic colours within a concert program that influences Ethan's repertoire choices. This insistence on a balanced colour palette within a concert program is similar to programming choices made by AP possessors, as indicated by Benjamin:

> BENJAMIN: Yes. Well first of all, if I'm programming a recital, I'm very, very conscious of the key relationships and the moods - the shifting moods - because each key feels like a certain thing and if the jump is too awkward - I wouldn't have a piece in B flat major and then F sharp major, it would just feel very wrong. So yes, I am very conscious of that.

As well as specifically choosing repertoire for a concert with complementary tonalities, AP possessors can be negatively affected by the lack of tonal relationship between pieces. When asked how a perceived lack of tonal relationship in a concert would affect him, Max stated:

> MAX: It happens often…I will feel slightly uncomfortable in the join between the two, in the initial stages. It's like having [pauses] an entree and then having

your dessert and then having your main course afterwards. You'd feel slightly uncomfortable but you'd get over it.

This potential discomfort informs Max's own programming decisions. When having to develop a concert program, Max chooses repertoire based on the tonal relationship between pieces, purposefully omitting prospective pieces if they do not meet this criterion.

6.2.1.2. Music listening preferences and aversions.

Name	***Condition(s)***
Mason	Synaesthesia and AP
Olivia	Synaesthesia and QAP
Mia	Synaesthesia and QAP
Isabella	Synaesthesia
Ethan	Synaesthesia
Thomas	Synaesthesia
Charlotte	Synaesthesia
Alexander	AP
Max	AP

As with the above-noted repertoire and programming choices, music listening preferences were similarly described as being influenced by either synesthetic percepts or tonality preferences.

The link between synaesthesia and listening preferences was strongly emphasised in discussions with synesthetes. One example was Isabella, who was asked during her interview whether her synaesthesia influenced her music listening choices, to which she replied: "If I know the key, yes! Like, *Don Giovanni Overture* I know is in D minor, and that song is really deep red, so if I don't feel like listening to deep dark red then I won't, or if I do…you know." Isabella indicated her listening choices were

often based on the desire to ‘see’ (or not see) a specific synesthetic colour, rather than to ‘hear’ a specific piece of music. Choosing to listen to a known piece of music to explicitly experience a particular colour percept was also noted by Olivia: “The Bach *Brandenburg Concerto*, I think the No. 3, I've wanted to listen to because it's so bright. When I've wanted to engage in that brightness, I've deliberately chosen that…The colour and the sound are bright. They're that yellow colour again. They're very, very sunny. It's an extraordinary piece of music.”

Synesthetes reported frequently listening to music that ‘matches’ a desired synesthetic output. Ethan, who (among other forms) has grapheme→colour synaesthesia, stated: “The majority of my listening time I spend on post rock, which is like the Icelandic band [Sigur Rós], like a Scottish band called Mogwai. They're kind of orchestral huge bands that just create waves of sound. It's almost like they're painting my numbers for me. It's just amazing.” Ethan described these bands as “painting” his grapheme-induced synesthetic percepts and acknowledged his enjoyment of this music stems in large part from the propitious ability of these groups to match his internally perceived coloured percepts. Like Ethan, Mason similarly indicated he “might be in search for a particular mood or a particular colour or aesthetic on a particular day and then be like, "Yeah, this is what I want right now,"” thus choosing a particular piece that will induced the synesthetic percepts he wishes to experience. Hence the desired outcomes of Mason’s music listening choices are habitually the ensuing synesthetic percepts.

Music listening preferences founded on the desire to experience specific synesthetic percepts can also be extended to include music playlists. Mia, for example, had compiled a playlist of pieces, specifying: “sometimes I'll just want something that has

a particular atmosphere. I have a playlist of blue things which, if I'm in a particular mood, I might prefer." Mia indicated 'blue' is "not a doing thing, this colour", thus Mia's blue playlist is preferred by her when she is in a calm mood, and "not particularly active". While the pieces in this playlist are not all in the same key, a higher percentage of them are "in the A keys". Mia indicated she physically perceives differing shades of blue in her mind's eye while listening to this playlist.

The choice to listen to a particular piece, based on its corresponding synesthetic percepts, is not, however, always a conscious one. Comparable to Mia's blue playlist, Thomas indicated his favourite colour is blue, and that tonalities that engender synesthetic variants of blue are keys he most often composes in. When asked if this preference for 'blue' tonalities also influenced his music listening preferences, he initially indicated he had never "thought about that", before acknowledging "a lot of the pieces on my iPod and stuff are in minor keys so they're more around C, D and G minor": keys that induce variants of the colour blue. Thomas furthermore conceded that there are "not very many bright red pieces" on his iPod – a noteworthy admission, as reds and oranges are his least favourite synesthetic colours. Thomas stipulated his iPod playlist choices were made "unintentionally", thus suggesting they were made instinctively and spontaneously.

While the desire to engage with satisfying synesthetic percepts can influence a synesthetes music listening choices, so too can the desire to avoid certain induced percepts. A synesthete may be aware of the musical merits of a composition, yet cannot overcome the synesthetic 'dissonance' that arises from compositional aspects of the piece, as the following example from Charlotte revealed:

> CHARLOTTE: I don't like Wagner and people have shown me parts of some Wagner compositions that in theory are quite nice and I can't, I just can't like it. I see the same colour every single time and it's that murky, browny green colour. And it's just something about how he composes or something about…I just…yeah! I can't do it!...A lot of the time with Wagnerian opera, it's so full on, that's where I describe it's like noise in my head. I see horrible colour, and it's noisy and I can't hear anything. It's just too much.

The avoidance of music by a specific composer due to the ensuing synesthetic percepts was similarly denoted, from a pitch analysis perspective, by AP possessors. Alexander, for example, signalled out the music of Prokofiev as "not my cup of tea", due to its lack of "nice progressions" and "nice major keys". Indeed, Alexander stated: "with that kind of music, I really don't know what key we are in for a start. I can't really analyse what's happening here. I don't see the emotional part of it. I think, because of that, I started telling myself that I don't like Prokofiev". Alexander contrasted his difficulty in analysing works from the late twentieth century with the predictability of modulations in music by Beethoven: a composer whose music he greatly enjoys. For Alexander, therefore, his enjoyment of music is heavily reliant on his ability to analyse the tonal elements of a piece: a task that is exacerbated in music that lacks a clear tonal centre.

Like Alexander, Max described how he will "steer away" from music that lacks an identifiable tonal centre: "[AP] has an influence on twenty-first and late twentieth century music sometimes when it's quite random. If it's not easily identifiable tonally,

I will have a bit more trouble with playing it and listening when learning it. So, I tend to steer away unless there's something equally captivating about the music." Even when a clear tonality is detectable, Max described often having an aversion to music that is not performed in its original key. Max stated that if two recordings of comparable quality were available to him, he would always choose to listen to the recording of a piece in its original key. He was similarly reluctant to listen to works that have been transcribed to other instruments in the event that this has modified the tonal centre of the work.

6.2.2. Compositional Choices

Name	***Condition(s)***
Xavier	Synaesthesia and AP
Benjamin	Synaesthesia and AP
Ella	Synaesthesia and AP
Samuel	Synaesthesia and AP
Ethan	Synaesthesia
Thomas	Synaesthesia
Charlotte	Synaesthesia
Lily	Synaesthesia
Joshua	AP
Henry	AP
Ava	AP

Composition is an activity central to the lives of many musicians, and participants in this study frequently reported the effect of synaesthesia or AP on their compositional choices. Of these participants, eight were composers or composition majors. This number includes six students, and two professional composers and lecturers. The effect of their condition(s) on their compositional decision-making is therefore an important factor to consider. Reports from participants, including composers, are examined in the following section.

The role of synaesthesia and AP in the compositional process was noted as occurring on three levels:

1. Enriching the compositional process through decisions based on synesthetic percepts or specific tonalities;
2. The potentiality for synesthetic percepts or tonality preferences to be restrictive when composing; and
3. The use of synaesthesia and AP as a practical aid during the composition process.

With examples from both synaesthesia and AP provided, a detailed analysis of these three facets follows.

1. The complementarity of synesthetic colours was frequently noted as being more important than musical considerations, while from an AP perspective the often-fundamental choice of tonality is habitually determined by the specific mood or characteristic of each individual tonality.

a. *Synaesthesia:* Synesthetes reported compositional choices are frequently made based on the synesthetic colours (or other percepts) they wished to 'compose' with. Ethan, for example, stated he makes compositional choices "based on colours, all the time", which occurs more frequently than choices based on musical considerations. Ethan noted that when composing, he will often find himself working from a single chord, as "the chord itself for me is interesting enough", implying the synesthetic percepts induced by the chord add a further dimension to the auditory aspect of the composition that greatly enhances its interest (see Chapter 5.1.2.1.1.: 'Enhanced

enjoyment of music'). Ethan stated: "Sometimes…all I'll have in a piano part is a chord because that's all I'm really feeling. Then I'll have to operate on that - keep the chord in there but change it up a bit to make it more interesting. The chord itself for me is interesting enough." This is similar to previous comment of his that parallels in music "*look* fantastic", and are therefore a tool he enjoys writing with, even if they are disapproved of in traditional compositional practice: "Colours go better together than harmonic changes. People say in harmonic writing, don't use parallels; watch out for parallels. Parallels sound fantastic to me, or rather parallels *look* [interviewee's emphasis] fantastic."

Ultimately, compositions can be written to centre completely on a specific synesthetic percept. Thomas provided the example of a Year 12 piece he composed entitled "Cold Blue", which was composed entirely of tonalities that induced variants of the colour blue for him: "I wrote the piece that only had blue in it. I…pick colours that I like and colours that go well together… D and D minor are blue; A flat and A flat major; F minor is also that darker blue, but they're the kind of chords and I write in those keys more often because they're that colour". As previously stated in Section 6.2.1.2. ('Music listening preferences and aversions') above, Thomas's favourite colour is blue, and his affinity with the colour is confirmed by his listening preferences. His decision to dedicate a composition to this colour by employing his synesthetic percepts as a compositional framework is therefore understandable.

b. *Absolute pitch:* AP ability plays a critical role in enabling possessors to choose the tonality, modality, or pitch centre of a composition. Absolute pitch possessors reported individual notes or tonalities as having distinct moods or personalities, which

would determine their tonality choices (see Chapter 7.2.2.2.1.: 'Note characteristic or personification as concurrent' and Appendix J for further discussion of the distinct moods or personalities of tonalities as reported by AP possessors). Joshua, a professional composer and lecturer, stated:

> JOSHUA: There are keys that I feel have more personality than others, I suppose. E flat would be among those, D, E maybe [sounding unsure]. I've got less strong feelings about F and G. They seem blander to me. D flat I think I probably have a strong sense of. Interestingly enough, they all seem to be clustered around the same part of the chromatic scale. I don't know if that's significant or not. I think that probably is accurate. The ones that I would have the strongest feelings about would be between D flat and E… I don't tend to write tonally, but in terms of central pitches around which something might gravitate, maybe that part of the chromatic scale is more central somehow. It feels more fundamental.

Music Joshua composes is thus commonly centred around this "more fundamental" section of the chromatic scale. The choice of modality, based on the distinct characteristics of specific tonal centres or tonalities, was similarly noted by Henry. As a composition student, Henry stated: "When I want a quieter section or a softer one, I might try for [pauses] a flat major key or C major, like a neutral one or something modal. So, it does have an impact." The converse is also true, with Henry indicating he perceives sharp keys as being more aggressive, and will thus employ them in compositions that mirror this mood. Individual tonalities are therefore an integral

element to his compositions and chosen purposefully to convey specific moods or characteristics.

2. Synesthetes and AP possessors reported that composing music based around their synesthetic percepts or tonality preferences can be limiting and can restrict the compositional process.

a. Synaesthesia: Charlotte noted that her synesthetic colours are of prime importance in her compositional decision making, and that composing a piece where her perceived colours matched together would be more important than composing one where the music matched. She also acknowledged that composing music based on a preconceived synesthetic template is both "good and bad":

> CHARLOTTE: I think it's helpful, definitely, with musical things like composing. It's hard because I'll make things that I like the sound of; I won't make things that necessarily fit what has been asked of us. So I'll have this thing and I'll like the sound of the chords. I'll like the colour of the chords as well but it might not be in the task. It might not be in the key they want it. If I'm trying to write something in a specific key and I don't like that key and I don't like that colour, it's normally a much worse piece. It's good and it's bad, I suppose.

For Charlotte, this aspect of her compositional process, which focuses on the synesthetic element, rather than on the musical merits of her composition, is limiting. Charlotte's opinion is shared by Xavier: when picking a chordal progression or key to

compose in, Xavier stated it is “always about the colour”. Xavier indicated he always starts his compositional process with chords, instead of melodies, as his synaesthesia is stronger for chords than for individual notes. While he described this process as “not good”, and indicated he understands that from a compositional standpoint there may be a more effective means of composing, he nevertheless indicated he is led by his synaesthesia to focus – at least initially – on the colours engendered by specific chordal progressions and tonalities. As also suggested by Charlotte’s previous comments, this clearly denotes a compelling internal drive beyond the control of synesthetes, and one they cannot easily override if or when desired. In this sense synesthetic percepts can be observed as being potentially limiting in certain compositional situations.

b. Absolute pitch: AP possessors frequently reported that once a particular tonality had been chosen, they would be unable to transpose the composition. Benjamin reported that the keys he chooses to write in are a vital aspect of his compositional process. He described conceiving of a piece in a certain key, and that this decision is non-negotiable. Not all keys portray equal feelings, even if they are of the same ‘mode’: for Benjamin, C minor is red, and goes well with rage and anger, while D minor is a “sort of blood-orange” and is more intense and broody. While this illustrates the unique character of each individual key, it also suggests why the transposition of a work into a secondary key could potentially modify the work’s very essence in the mind of the AP possessing composer. As a composition student, Ella indicated that transposing any of her music would be problematic for her, as she views the key or modality of her pieces as “really important”. Not only does her own music sound wrong if transposed, but she also stated that the whole “mood” changes,

which is unexpected and confusing for her. The tonality of a specific composition is thus an integral part of the composition's framework.

Internally generated musical ideas, used in the compositional process, are similarly reported as being 'fixed' in their originally perceived tonalities. Samuel indicated he uses his involuntarily auditory imagery as compositional material: an activity he described as cathartic, particularly in alleviating his anxiety and depression. Composition was previously a more committed activity for Samuel, but he is currently more focused on performance; composition is, however, still "under consideration" as a potential aspect of his future career. He did mention, however, that AP was vital to his ability to transcribe his internally generated musical ideas. Yet one potential downfall of the use of his AP within the transcription process is his insistence on writing his internal music at pitch, as Samuel will not transpose it while transcribing, even if he is conscious that the key he is writing in is an awkward key to play in: "When I hear music inside and I write it down, I write it at that pitch and sometimes it gets very awkward for instrumentalists because it's in a really bizarre key." This inflexibility is one of the negative aspects of AP ability noted by possessors as restricting their compositional process.

3. Several participants indicated their synaesthesia or AP could be used as a practical aid during the composition process.

a. *Synaesthesia:* Lily provided the example of how her synaesthesia facilitated her ability to write serial music, whereby her induced synesthetic colours enabled her to formulate twelve tone rows, and compose in diminished or whole tone harmony. Not

only did Lily indicate this was possible purely from an internal compositional perspective, but she stated she is able to actively use her synaesthesia to derive inspiration from external sources:

> LILY: I've written pieces of music based on paintings: got the tone rows from the paintings and then written pieces using that which is quite useful…I was using Kandinsky (he's my favourite painter) and I think he's my favourite painter because of the colours that he uses. When I look at Kandinsky, I do actually sort of hear the colours in a more direct way. Without necessarily thinking: for orange, that's a perfect fourth. It has more immediacy for me. It seems to bypass that connection a little bit. A lot of his paintings look to me like graphic scores, even when they're not using colour.

Using paintings by Kandinsky as an additional source of material for her compositions holds special significance for Lily, as she has heard Kandinsky may be a synesthete himself. Lily indicated the utilisation of her synaesthesia in these instances is an "active utilisation", which enhances her compositional decision-making process.

b. *Absolute Pitch:* In the previous section, Lily indicated how her synesthetic percepts aided her ability to compose serial music, and from an AP perspective, Ava reported the same assistance from her AP:

> AVA: Last week we had a serialism composition [laughs] to do. So doing the matrix and everything was pretty fine. Knowing what the pitches would sound like in a non-conventional harmonic sense was quite useful for me as well. So

> it wasn't just like notes on a page because that's number 1 - 12 and that's the process - I'll just do that; I think I actually managed to make something that sounded okay.

Ava was therefore able to employ her AP to internally hear individual pitches in situations where conventional harmony was absent and use this pitch information to construct her composition.

A further application of AP that was reported as being used during the compositional process was the ability to transcribe musical ideas. Henry, a composition student, noted: "I would have the idea and I would know the notes because I know the notes already [laughs]. In that regard, yes - it definitely helps…. Knowing the notes, it's easier to memorise or expand on the idea. I guess I would be a bit lost if I have an idea and I don't really know the notes." Henry's ability to transcribe his internally generated musical ideas, facilitated by his AP, is of considerable practical assistance to his compositional methodology, and allows him to "expand" on his ideas freely.

6.2.3. Instrument Preferences

Name	***Condition(s)***
Lily	Synaesthesia
Charlotte	Synaesthesia
Ruby	Synaesthesia

One of the more common forms of music-related synaesthesia is instrument sound→colour synaesthesia. Indeed, eleven of the eighteen synesthetes in this study (61.1%) were diagnosed with this form of synaesthesia. Consequently, the effect of

induced colour percepts on choice, preference, or aversion to certain instruments, warrants consideration. Three synesthetes in this study – Lily, Charlotte, and Ruby - offered striking examples of how their synesthetic percepts influenced their instrumental preferences.

Lily has several forms of synaesthesia, including instrument sound→colour. She indicated that her strongest colour associations are for instrument timbres that she dislikes, such as the saxophone, which produces a horrible muddy yellow colour. Indeed, Lily stated that instruments that produce a nasal sound will engender a strong colour association, and it is both the sound and corresponding colour that she dislikes. She referred to the induced colours in these instances as a "distraction", while furthermore noting they provoke a strong aversion to these instruments. Lily described how the colour of an instrumental tone that she does not like – such as the muddy yellow of the saxophone – overrides any intervallic or individual note colour that she would normally experience. As such, any note or interval played on the saxophone induces the same overriding muddy yellow colour. This, she estimated, is because the colour is so "strong". The overbearing nature of the colour greatly affects her ability to work with saxophonists (whom she admitted to not wanting in her band), to play or listen to the saxophone, and even to date a saxophonist (said tongue-in-cheek, but nevertheless truthfully by Lily).

Another participant who equally strongly dislikes the sound of the saxophone, and likewise perceives a horrible yellow colour when hearing it, is Charlotte. While Lily perceives a "muddy" yellow colour, Charlotte perceives a "bright" yellow colour: "If I think about saxophone - I don't really like them very much. They're always this

horrible - it feels like it hurts - this shade of bright highlighter yellow." Charlotte also perceives this same yellow colour for other instruments, such as the "oboe that's not played well", chimes, or vibraphone, insisting: "they're all that horrible bright yellow." It is interesting to note that, like Lily, Charlotte indicated this strong yellow colour overrides all her other forms of synaesthesia. When it is an instrument she likes, the colour induced by the timbre of the instrument, and the colours induced by elements of the music itself (such as tonality or pitch), forms layers of colours in her mind's eye. When the instrument playing has a timbre she dislikes, however, this layering effect is stifled: "if it's something I don't like - I don't like saxophone - that's all I see. I see that colour that is that instrument and everything else feels like it's been blocked out. I can't hear the music in any other way than that." This aversion to the saxophone in particular would strongly influence her ability to play the instrument, with Charlotte emphatically stating: "No, there's no way [laughs]!"

Finally, Ruby recounted how her choice of instrument was affected by her synesthetic percepts. Ruby learnt the flute as a child but noted the instrument "didn't suit me [laughs]. It didn't gel", while also mentioning she had always wanted to learn the cello. When asked if her synaesthesia played a role in these instrumental preferences, Ruby replied:

> RUBY: [Laughs] Yes, I think it has. I didn't want to play the flute. I didn't like its colour…I always wanted to play the cello and that definitely felt right and it felt like the right colour. So yes, I think it has - definitely. … I think it would have been a motivation to stop doing what I was doing. I remember [laughs] I

> really, really hated the flute…It was just this utter loathing of it. I hated everything about it.

Ruby indicated the disagreeable colour induced by the flute was a reason "to stop doing what I was doing", while the pleasurable red colour induced by the cello "would certainly mean an attraction" towards it.

6.2.4. Summary of Choices and Preferences

Statements from participants in this study revealed that decisions relating to repertoire and concert programming, preferences regarding music listening, and musical style preferences, are regularly and compellingly influenced by the possession of synaesthesia or AP. Furthermore, composition choices and instrument preferences or aversions were also reported as being guided by the associated concurrent percepts or associations of these two conditions.

Synaesthesia and AP were affirmed as playing a seminal role in participants' musical preferences, including repertoire choices, programming decisions, listening choices, and stylistic preferences. Synesthetic percepts and AP associations were both confirmed as being determining elements of the appeal of certain musical styles, works by specific composers, and tonalities.

The role of synaesthesia and AP in the compositional process was acknowledged as occurring on three levels. Reports from synesthetes indicated their synaesthesia greatly informs their compositional process yet can be both constructive and restrictive. Synaesthesia can also be used as a compositional aid. Synesthete

composers indicated choosing tonalities, chord progressions, or individual notes based on the induced colour percepts they wished to produce. Furthermore, the desire to produce specific synesthetic percepts was noted as often priming over specific musical considerations.

Reports from AP possessors were strikingly similar, with participants indicating AP influenced their compositional decision-making, particularly in relation to the choice of tonality, modality, or tonal centre. As analogously recognised by synesthetes, these influences are either facilitative or restrictive, while AP can also be used as a technical aid when composing.

All composition students and staff members reported that their synaesthesia or AP is influential, to various degrees, in their compositional decisions and output, while other participants in this study also reported these effects.

Finally, synesthetic colours induced by the timbral qualities of musical instruments were also reported as potentially influencing a synesthete's preference or choice of instrument. A preference or aversion to a particular instrument was furthermore reported as influencing several aspects of a synesthete's musical decision-making, including choice of group instrumentation or involvement, listening preferences, and musical style preferences.

6.3. Performance

"Each tonality is personified. Each tonality has its associated colours. So that's why transposition can be very annoying to me."

Mason (Synaesthesia and AP)

During the interview, participants were questioned concerning the impact of synaesthesia and AP on performance aspects of their musical engagement. Within the responses of participants, three performance facets were emphasised as being considerably impacted by the possession of synaesthesia or AP. These three facets are examined in the following section. First, the impact of these two conditions on music interpretation is assessed, with examples from both synesthetes and AP possessors provided. Second, the potential for synaesthesia or AP to enhance or obstruct the development of technical aspects of musical performance is evaluated. Third, transposition difficulties that arise as a direct consequence of AP possession are examined. Included in this assessment are examples of the adverse impact of AP on written transposition, playing a transposing instrument, and listening to or performing at baroque or classical pitch. Were applicable, examples from synesthetes are also provided.

6.3.1. Interpretation

The interpretation of a musical work is a process that requires musicians to decide how to perform music that has been previously composed. As music notation is inherently imprecise, interpretation is a fundamental aspect of any performance. This

subsection investigates the effect of synaesthesia and AP on interpretational decision-making.

6.3.1.1. Synaesthesia.

Name	***Condition(s)***
Charlotte	Synaesthesia
Thomas	Synaesthesia
Ethan	Synaesthesia
Isabella	Synaesthesia

Music-induced synesthetic percepts were reported as influencing the perceived mood, and therefore interpretation, of musical compositions. Associating specific moods with synesthetic colours impacts how a piece is learnt, and how it is interpreted. Charlotte stated: “I feel like when I can see things, I'm much more expressive,” and furthermore noted that if she does not perceive a colour for a certain section of the music she is performing, or if the colour is not as expected, this would prompt her to change her interpretation, to maximise the potentiality to produce the desired synesthetic effect: “I've known that when it's not there, then something is wrong. I need to be doing something to make it appear to me in the way it would.” Charlotte furthermore noted that she judges the success of her interpretation based on the precision of the colour she perceives when performing.

Thomas reported a comparable interpretational process to that employed by Charlotte, with Thomas indicating he uses his synesthetic colours as a template, modifying his interpretation to fit his internally perceived colours. Thomas stated: “If I hear something in a different colour, I'll change the way that I play it.” This is particularly true in regards to the tonality a piece is composed in: for example, a piece performed

in C major is “more boring” than if it were performed in C sharp or D, as these two keys induce synesthetic colour percepts while C major “is just clear”. Thomas indicated that while he cannot adjust his interpretation to change the tonality of a piece, he would “put more emphasis on the colour of individual notes than on the overall phrase” if the piece is composed in an unfavourable key. Thomas thus focuses his attention on individual notes instead of on the “boring” tonality as a whole, which enables him to interpret the piece more successfully.

Similarly to both Charlotte and Thomas, Ethan also affirmed: “Yes, when I see colours, they change my emotions in how I'm playing for certain pieces.” What Ethan subsequently noted, however, was that this reliance on his synesthetic colour percepts when interpreting music can be inhibiting. Rapid changes of tonality engender equally rapid changes in colour, and Ethan conceded this hindered his ability to transition smoothly through these changes of colour and mood. To further compound this difficulty, Ethan noted that individual tonalities induce specific moods, and that “depending on the colour or key I am playing in - I will play in a different kind of mood…music with all those notes, colours and emotions are all tied together, I find. My teacher's just like: "You've got to make it more happy!" And I'm like, "But it's in G minor! It's really hard!" It's frustrating.” This he believes is “very closely tied to the synaesthesia.” Thus it is both the tonality and colour that can restrict Ethan’s interpretational options.

The potentially restrictive aspect of synesthetic percepts was highlighted by Isabella, who reported a recent example of how her synesthetic percepts did not match the mood of a piece she was learning to play:

> ISABELLA: It's funny, I was playing this Rachmaninov etude and it was in E flat. I associate that key with probably the more light Mozart stuff. This piece was really pounding. You've got to be attacking the note: a completely different touch, but I was playing more with a lighter touch and trying to make everything smooth.

For Isabella, E flat induces a synesthetic light blue colour, which Isabella conceded is a softer colour, and thus influenced her lighter interpretation of the music:

> ISABELLA: Maybe that piece being in that key was a bit - it should be in a harsher colour. But I was never really conscious of it…I think it does affect it. I think if that piece had been in D, which is red and angry, I would have probably been more inclined to bash it out. It's so weird. I didn't really think of it.

The synesthetic colours she perceives therefore influence the way Isabella shapes her expressivity and sound production, while the "ideal sound to colour characteristics" she wishes to achieve thus guide her interpretational decisions.

Overall, synesthetes noted that plotting their musical interpretations in terms of colours, and the strength and fit of these perceived colours, is an important guide that is frequently followed when interpreting music. This process can enhance interpretations, specifically when synesthetic colours are perceived as being fulfilled or matched in a performance setting, while the mismatch or absence of colours can be

seen as an indication of a poor interpretation. Furthermore, synesthetes reported the interpretation of certain pieces based on their synesthetic percepts could be restrictive, specifically in relation to the tonality of the piece.

6.3.1.2. Absolute pitch.

Name	***Condition(s)***
James	Synaesthesia and AP
Liam	AP
Max	AP
Sienna	AP

Absolute pitch possessors indicated that both the ability to label and situate individual notes, and the key a piece is written in, will affect how they interpret music. Liam stated that being able to identify individual notes within a piece enhanced his ability to interpret specific musical phrases:

> LIAM: [Pauses] Oh yeah. So in the slow movement of the Haydn string quartet for example, there'll be a lot of tension on certain notes: the leading notes or clashes against other notes. I think most decent musicians would do the same. They would - even if they didn't have AP - want to bring it out. But perhaps the awareness that I've got a C sharp clashing against a D that I'll hear and be able to identify where it is in the quartet based on either being able to hear it and feel it, it might bring that out more. So, I think that definitely identification of the notes - the AP would help the interpretation, I would think.

While individual notes can be used to frame a musical interpretation, AP possessors also employ the distinct characteristics of specific tonalities. James, for example, stated a piece can evoke different emotions if the tonality of the piece is changed, and thus influence his interpretation of the work. This was similarly reported by Max, who stated that although different tonalities may express variants of a similar underlying emotion, these differences strongly influence his interpretation of the piece:

> MAX: So, the most important example is when you have a minor key and it's either angry, sad, restless or anxious…You can get things [pauses] [sighs] that are wistful, mournful, distant or [pauses] reminiscent of certain moods, so things that aren't obvious that suggest different characters. For me, I hear that constantly. So, when I say emotion with sound, that for me is intertwined with interpreting music.

Max described his phrasing and interpretation as being "dependent" on his AP, and that he would be "completely lost" without it:

> MAX: I suppose I cannot separate the direction from the note. So, if something goes up and we get louder, that's not enough for me. I need to hear the pitch of where it goes. I need to know the actual note for me to also shape the particular phrase. So, without knowing what the note is, I feel that I don't know where I'm going. So, I don't know the harmony, I don't know the key. I don't feel that I am interpreting correctly. So when I'm playing music where I can't really hear what I'm playing and I'm following a pattern, I'm completely

> lost. I might recognise the pattern, but I don't feel confident in the same way as when I'm playing a particular line.

Music in which Max is not able to easily identify a tonal centre will be more difficult to listen to, play, and learn. This prompted Max to "steer away" from twenty-first and late twentieth century music, unless "there's something equally captivating about the music". For Max, however, "harmony and listening to keys is a big part of how I interpret things. So, it's quite important to have that."

One further example of the potentially restrictive nature of AP possession on musical interpretation was provided by Sienna, who noted her propensity to 'mimic' recordings she had previously heard. Sienna is heavily reliant on listening to recordings when memorising music. She rarely looks at the score of the work she is learning – sometimes not at all – and acknowledged this may not be the best way to learn. Indeed, Sienna referred to her AP as "a double-edged sword". This can create bad habits, as illustrated in an annoying aspect of her acute memory, whereby if a wrong note is played in an orchestral setting, she will recall the music - and listen to it in her mind - with the wrong note included. This internal auditory recollection will occur again and again, with Sienna admitting: "this drives me insane." Listening to recordings is a "bad habit" that results in her "falling into staleness and just doing what you're used to", and "not being creative". She reported she was aware of needing to make sure she does not become reliant on recordings: "There are dangers of not forming your own interpretation; no one wants a boring performer." Her reliance on her AP worries her and she acknowledged she should put more thought into the stylistic decisions she is making. Sienna noted: "In that way, I need to separate

myself." This, for her, is the "danger of learning by ear": a learning style directly influenced by her AP.

Overall, AP possessors indicated that both their note labelling ability, and the specific characteristics and moods of individual tonalities, influenced their interpretation decision-making. This influence was both positive and negative, with possessors noting both an enhancement of their ability to emphasise structural and emotional elements of a piece, and the potentially restrictive nature and difficulties AP could cultivate.

6.3.2. Technique

Name	***Condition(s)***
Mason	Synaesthesia and AP
Charlotte	Synaesthesia
Ava	AP

When describing the potential for either synaesthesia or AP to influence technical aspects of performing, a dichotomy existed between participant reports, with both conditions noted by different participants as enhancing or hindering instrumental technique and learning.

Mason has synaesthesia and AP, and indicated both conditions enhanced his technical abilities in violin performance in different, yet complementary, ways:

> MASON: [Pauses] So the perfect pitch helps when playing in tune, a technical one. In terms of the synaesthesia, it forces me to think about how I produce my sound. With violin, the main thing's vibrato, but also the bow control.

> Then just thinking about, "Is the sound too hot? Do I want it to be this way?" Say I didn't want it to be that way, I might make a lighter vibrato that's not so fast. Just the characteristics of the sound in terms of flavour but also temperature, as I mentioned. Then figuring out if it's too much one way or the other and doing what I can to adjust. If I can't or don't have the technical ability to adjust, then having that sense of disapproval or discomfort.

Mason indicated he feels a sense of satisfaction if he is able to adjust his playing to match the "ideal picture" of how he wanted his playing to sound. Conversely, if he is unable to match his desired synesthetic output, he feels "quite bothered or annoyed".

When practicing, Mason often focuses on aspects of sound production, based on his synesthetic percepts: "I'll have a very specific sound quality in mind. Sometimes I might spend ages just trying to get that right sound rather than thinking that the note sounds fine and going on to the next section." Mason therefore views achieving a level of proficiency through the application of his synesthetic percepts in his practice regime as positive.

Only two participants - Charlotte (synaesthesia) and Ava (AP) - noted a potentially negative effect of their conditions on specific technical aspects of their instrumental playing. When asked to imagine what might be different had she not had synaesthesia, Charlotte responded:

> CHARLOTTE: That's really hard to do! I almost feel like I would have been a more technique-focused player, more technically adept. I feel like that has

always been something that I haven't quite conquered. I'm not the most technical player. I think maybe if I didn't have synaesthesia, my focus on that would have been different because everything is so related to expression and colour and these images and things that it's all about the sound. It's not so much about how my fingers work and that sort of thing. Whether my embouchure's right! I feel like that would have made a difference.

The focus of attention on her synesthetic percepts was noted as being detrimental to technical aspects of Charlotte's playing. This opinion was shared by Ava who, as an AP possessor, noted a similarly negative effect. Ava reported her AP ability was detrimental to the development of certain technical aspects of learning the cello:

AVA: In terms of learning, retrospectively looking back it can actually be a bit of a curse because you're learning this on the page so quickly that often other things get lost. I've actually spoken to my old teacher about this. Because you're processing the music so quickly, you don't want to slow someone like that down to say, "Hang on, let's work on these technical aspects instead." You want them to stay interested and focused. If you gave someone with that ability to have that quicker learning and processing time, you don't want to say to them, "Okay, you're going to play this for X amount of months until we fix your bow hold." The first thing you're going to do is say, "Well, why am I doing that? I can read the music, I can play it, I can do it in tune, I know everything I'm doing." In a way, it can be a detriment in that sense.

One technical aspect of her playing that Ava identified as having suffered due to her AP is her ability to shift positions on the cello. She was recently "told off" for shifting too quickly and stated: "Maybe that's something to do with knowing the note you want to hit. Then if you don't hit it, it's like, "Oh, what have I done?" You can hear it, but you might not have trained your fingers…Slow shifts, slow down the shifts and it means that you can just find the pitch somewhere." Because of her AP, Ava was able to employ a different methodology to find notes at the top of the fingerboard, without having to learn the technical motions to arrive. Ava declared this difference in learning style led to the fact that much of her "basic technique isn't as good as it should be."

Ava's enhanced speed of learning also negatively impacted her motivation to practice: "I felt that I could rest on it. I was never a practiser. I could wing my way through most situations and I've never been a huge hard-working practiser because it's always at that stage where I'll be able to do it - I can do it. You become quite lazy about it, I think." Ava indicated she believes her lack of practice as a child was due to AP, which facilitated her musical understanding, and decreased her perceived need to practice.

6.3.3. Transposition

Name	***Condition(s)***
Mason	Synaesthesia and AP
Mia	Synaesthesia and QAP
Ava	AP
Liam	AP
Emily	AP
Lucas	AP

The ability to transpose music, both as a written exercise, and also while playing or singing, was exclusively reported by AP possessors as being negatively affected by their condition. Observing the difference that exists between how absolute and relative pitch possessors transpose, Ava noted: “what people without AP would do is they follow the contours of a score when they read rather than follow the notes. If you're doing it by contours, it's quite easy - surely, but I've never read like that. It just adds another process when you're doing something like that - of thinking, "Okay, that's an E," and then three above that or whatever below. I do find it tough doing that.” Ava reported her AP was “too automatic” for her to switch it off and follow the contour of a piece when transposing.

Other AP possessors, such as Liam, admitted to fighting against any situation that requires transposition, with Liam indicating he would have to eventually abandon how he typically reads a score, opting instead to concentrate on the phrasing of the music (as a musician without AP would). He does, however, find this exercise extremely challenging. Indeed, Liam stated he is “completely lost” when transposing, and feels his relative pitch (RP) is negatively affected by his AP: “I would just get stuck and not know - wouldn't be able to continue.” He claimed he is unable to turn his AP off, even in such situations where it would be beneficial for him to be able to do so.

Absolute pitch possessors recurrently noted the underdevelopment of RP skills as a negative by-product of their AP ability. Emily, for example, noted her AP distracted her from interval training, indicating she would isolate individual notes when asked to name an interval or sing intervallically: “Sometimes I have trouble with intervals

because I'm trying to think of how the next note should sound instead of just the interval itself…If there's a B and they tell me to sing a minor third, I'll try and think of the D and then sing it up instead of the quality of the interval itself." Emily stated she believes this slows down the interval-naming process and makes it less effective. This reliance on AP, to the detriment of the development of RP skills, was even noted by Lucas as the 'worst thing' about having AP:

> LUCAS: The worst thing about it [AP] is the risk of developing a reliance on perfect pitch without having initially crafted or cultivated relative pitch for intervals…I think musicians or people wishing to pursue music who have perfect pitch should be made aware that yes, your pitch may be good, but there are other aspects. It doesn't solve all your problems. It gives you a leg up in some areas but not others.

Absolute pitch is thus commonly used as an ineffective interval naming or producing strategy. The detrimental effect of AP on the development of RP abilities is therefore an important aspect of the difficulties faced by AP possessors when transposing.

Although transposition difficulties were exclusively noted by AP possessors in this study, participants with both synaesthesia and AP reported that mismatched synesthetic percepts validated and enhanced these complications. Mason described that when he is in a situation where he needs to transpose music, either when singing, playing, or as an exercise, his AP and synaesthesia combine to impede his ability to do so:

> MASON: Each tonality is personified. Each tonality has its associated colours. So that's why transposition can be very annoying to me. If I'm singing in the choir and then you drop, I'm not thinking in intervals as much as you should as a musician, I'm just thinking, "Does this feel like D major or does this feel like - "…Sometimes I have to trick my brain into rearranging the associations of that key and putting it into that lower key so I can picture that as what it's named as opposed to what I'm used to hearing.

Tricking his brain in this way is not always successful, particularly in relation to instrumental music, where he has very little tolerance for changes in tonality and feels the music "has to stay where it should be". Mason reported it is the dropping pitch that is the main annoyance in this situation, however the colour aspect of his synaesthesia reinforces this difficulty. Like Mason, Mia also believes it is her AP that is the dominant reason for her transposition difficulties: "I think it's mostly the AP but then it's a bit confusing because the colours aren't quite what you're expecting." Both conditions therefore interact and reinforce the difficulties that arise during transposition exercises. Mia also noted she does not think of music in relative pitch terms, and as such reported it is easier for her to transpose while singing if the music is in a different clef, or if the interval between the note she is reading and the note she is singing is larger. Indeed, Mia stated, "a second and a minor second are really bad." Thus, changes in clef, transcription interval size, and whether the transposition exercise is written, vocal, or instrumental, will all affect the success of the task.

6.3.3.1. Playing a transposing instrument.

Name	*Condition(s)*
Benjamin	Synaesthesia and AP
Mason	Synaesthesia and AP
Charlotte	Synaesthesia
Henry	AP
Oliver	QAP

The ability to play a transposing instrument was frequently noted by AP possessors as being "impossible", and that if attempts to do so were made, these attempts were impeded by their condition. For AP possessors, visually following a score in one key, and transposing it automatically into another while performing, was frequently reported as being an incredibly difficult and complex process. Henry, for example, described his transposition skills as "awful", and mentioned he needs to write out any transpositions he is required to play (such as when accompanying a singer), as he is unable to play while transposing at the same time. He cannot, for example, simply press the transposition key on an electric keyboard, as the exercise of physically playing in a particular key, but hearing a different one at the same time, is impossible for him. This difficulty was also noted by Oliver, who stated:

> OLIVER: There was always a curious phenomenon with the keyboard where if I hit the transpose button, my fingers would kind of want to go to the patterns of the key that I'm hearing. This was a rich amusement to me because I'd be playing in C, hit the transposer it to put it into E flat, and my fingers would just want to be in the space where E flat is and I'd laugh at myself. That would seem silly.

On one occasion, Oliver worked with a singer, using a transposing keyboard to choose the tonality of the songs for a concert. Oliver found this exercise "disturbing", as the written notes of the score did not match what he was hearing. The difficulty he faced in playing pieces transposed to accommodate the voice range of a particular singer was paralleled in comments made by Benjamin. Benjamin noted that playing in one key and internally hearing in another key forces him to "work *really* hard - and I mean *really* hard [interviewee's emphasis] - to block out the sound that I'm hearing and play the right keys for the right notes on the page because that's easier than trying to transpose it in my head and risk getting a wrong note." Benjamin does nonetheless continue to feel a kinaesthetic desire to move his hands into the 'correct' position on the piano (based on what he is hearing), acknowledging this sensation is "frustrating and I don't enjoy it." Accordingly, Henry, Oliver, and Benjamin all reported their AP hindered their ability to play on a transposing keyboard, or to accompany other musicians using transposed music.

As with discussions of transposition in general, difficulties in playing a transposing instrument were almost exclusively reported by AP possessors, although synaesthesia was again noted as being associated with this difficulty for participants with both conditions. Mason, for example, stated that while the changes in pitch would "mess with my head a lot", he acknowledged, "both synaesthesia and perfect pitch are linked. You'd be expecting a certain colour or characteristic and then it wouldn't be there. It would be quite confusing or baffling." Only one synesthete participant – Charlotte – indicated her synaesthesia hampered her attempt to learn a transposing instrument (the clarinet):

> CHARLOTTE: The problem I found was that even though the clarinet faces another way, the fingers are very similar to flute and the sound is not what I expect. It's not so much the sound - it's the colour that's not what I expect. The pictures still happen to the sound or those shapes still happen to the sound that I expect from the flute, where it would be on the flute. And I find my fingers suffer because of that. I try to do what would feel natural for the flute and it's not on the clarinet.

Charlotte indicated it is particularly the colours, images, and shapes induced by the clarinet that do not meet her expectations, causing her technique and finger work to "suffer".

While the difficulty to play a transposing instrument was predominantly reported as being caused by the AP-induced juxtaposition of the read and heard pitch, the mismatch of synesthetic percepts was also noted as either enhancing or triggering these complications (see Appendix I for a tabulation of paradigmatic quotes).

6.3.3.2. Different pitch systems: baroque and classical pitch.

As an extension to the previous discussion on transposition and transposing instruments, the question of listening to, or performing in, pitch systems that deviated from A=440 was broached. Absolute pitch was reported as hindering possessors' abilities to both listen to and perform music at baroque and classical pitch.

6.3.3.2.1. Listening to music at baroque pitch.

Name	***Condition(s)***
James	Synaesthesia and AP
Mason	Synaesthesia and AP
Benjamin	Synaesthesia and AP
Alexander	AP

Participants with AP noted the difficulty they faced when having to listen to music performed at baroque pitch. Statements such as: “The baroque tuning. Hearing something that was different from what I know is my standard of pitch (or what is modern day standard of pitch) was driving me insane” (James), “I would start jumping up and down, especially if it's baroque music” (Alexander), and “If I listen to things like baroque music where it's pitched differently, the distracting notion in my head telling me, "This is in another key" and then you're trying to say, "Shut up, I'm just trying to listen to the music! I don't want you bothering me right now!"” (Mason), all serve to illustrate the negative impact of AP on a possessor’s ability to accommodate different pitch systems.

Benjamin is an interesting case study, as baroque music is the style of music he has chosen to play, sing, and in particular study now at a postgraduate level. It is his preferred style of music, and his reasons for this are manifold. When asked what attracts him to baroque music, he stated:

> BENJAMIN: [Pauses] Well I think I love the style and the structure and the fact that baroque music is so - classical music as well - rooted in keys. It's diatonic. Romantic music, obviously I love it, but those chromatic modulations and things …With the whole colour thing and AP thing it's very

> settled and I like that about baroque and classical music. I think also the sound of period instruments, there's a richness to them that is so exciting. So D flat major on the period ensemble - D major, rather [laughs] (I'm getting confused now) - isn't the same as if an orchestra was playing the same piece in D flat major. It would be at the same pitch, but the sound of the gut strings and whatever that encompasses is exciting.

Despite these reasons, the problem of the juxtaposition of his AP preferences with baroque pitch has been a struggle for many years and continues to be difficult for him to cope with. This first became apparent to him at the tender age of seven. He related:

> BENJAMIN: … I can remember the first time it was a problem for me: I was seven and I heard the "Gloria" and the "Dona Nobis Pacem" of the Bach *B minor Mass*. It was at period pitch and I thought, "Ooh, it's in D flat! How exciting!" And then I went and got the score because I used to conduct to recordings (I know, so embarrassing!). And it was in D major, and I was like, "I can't believe it! Why have they got it in D flat?! It's D!" I didn't understand.

Aside from providing us with a further indication of his precocious and special engagement with music, this anecdote demonstrates the continuing difficulty he faces in trying to marry what he is hearing to what he is reading. He indicated that if he hears a recording of a work before seeing the score, the heard tonality would be the key he remembers the music by. Any subsequent reading of the score will therefore always appear “wrong” to him (even though the written key is the ‘correct’ key).

Thus, Bach's *B minor Mass* is instead remembered by Benjamin as the B flat minor Mass, and he will conceive of the piece as such.

6.3.3.2.2. Performing at baroque or classical pitch.

Name	***Condition(s)***
Benjamin	Synaesthesia and AP
Lucas	AP
Liam	AP

Performing in a pitch system that differed from concert pitch was frequently noted as being hindered by the possession of AP. Benjamin noted that the act of singing at baroque pitch, and therefore at a different pitch to what he is reading off the score, is very difficult to do. The distress this causes him is multifaceted:

> BENJAMIN: … It would cause me such distress for a whole host of reasons: because I was wrong [laughs]; because I wasn't doing what everyone else was doing; I knew that I was wrong but I couldn't do anything about it (no matter how musical I am); the fact that they are singing in a key that I'm not seeing on the page so what I'm hearing in my head is different from what I'm hearing from them. So it's actually a physical or an actual aural dissonance that I'm experiencing. *Very* unpleasant, *very* unpleasant [interviewee's emphasis].

Note Benjamin's insistence on emphasising both the physical and auditory dissonance he is experiencing. Lucas, who described his AP as both a "blessing" and a "curse", provided a further example of this difficulty. Until recently, Lucas had not had any real exposure to formal musical training, and as such, couldn't comfortably read music. This inability to sight-read was reinforced when he initially became a member

of one of the university's choirs and encountered baroque music for the first time as a performer. At this time, Lucas was by his own admission "very uninformed", and unaware of what baroque pitch was:

> LUCAS: We did Bach's *Saint John Passion*. I could see an A on the page and I could hear everyone singing in A flat and I thought, "What the hell is going on? Does nobody else realise?" I was freaking out! I was like, "What the fuck is going on?" Then someone said to me, just as an aside, "This is baroque pitch. We do it a semitone down." I thought, "Oh right! What is this?!" I'd had no formal training up until that point, so baroque music last year was a very foreign concept to me. I was like, "Why? Why not just do it at the pitch that it's written at?"

The juxtaposition of his lack of sight-reading skills and his AP ability meant Lucas was unsuccessfully using his AP to sight-read. This resulted in a situation where he would try to momentarily switch off from what he was hearing around him and use his AP to internally hear the following note. Externally hearing 'flattened' baroque pitch notes was, however, "exceptionally difficult" for him. His inability to use relative pitch to sight read, and his reliance on his AP to do so, resulted in what he himself describes as an "inefficient" strategy (see Section 6.3.3.: 'Transposition' above).

The difficulties to sing in baroque pitch, reported by Benjamin and Lucas, were similarly noted in an instrumental context by Liam. As a violinist, Liam has had the opportunity to play at both baroque pitch (A=415) and classical pitch (A=430). He

described the difficulty he faces in performing at these pitches when unsuccessfully trying to "force" himself to turn his AP off. Because of the strong connection he feels between pitches and fingering on the violin, he finds the physical manifestation of placing his finger in a certain position and hearing a pitch that does not correspond to his internal template of that pitch disconcerting. Consequently, his immediate inclination is to shift his finger to align it with what he expects the pitch to sound like. Liam has great difficulty overriding this sensation, even though the sound he is producing is correct in the context of the ensemble he is playing with. He described the fact that he feels the urge to "fight against it" through his fingers as a potential limitation of having AP, and the manner with which AP has affected his approach to listening. While both baroque and classical pitches confer difficulties for him, he finds adjusting to baroque pitch easier. This, he posited, is due to the fact that baroque pitch – while a full semitone flatter than concert pitch – is comprised of notes that fit the standard pitch template. In contrast, classical pitch sits in between two standard notes, and Liam is therefore under the constant impression that the note is flat and is therefore left to approximate with his fingers and "guess a bit with the pitch". What is fascinating in this example is that he is unable to override his AP by listening to his playing contextually, thus underscoring the supremacy of his internal AP template over the exterior manifestation of the flattened template.

6.3.4. Summary of Performance

Performance aspects of music engagement, including music interpretation, technical aspects of performance, and various facets of music transposition, were all reported as being impacted by the possession of synaesthesia or AP. An analysis of the results

demonstrated that individual participant statements were highly idiosyncratic, with both positive and negative outcomes conceded.

Both synesthetes and AP possessors indicated their conditions considerably impacted their interpretation of musical excerpts, providing examples of both enhancements and restrictions to the interpretative process. Synesthetic percepts and the distinct characteristics of individual tonalities were reported as being used to frame musical interpretations, thus influencing the perceived mood of the piece. This interpretative guide consequently enhanced the ability of possessors to emphasise the structural and emotional contents of the piece. In contrast, synesthetic percepts and AP associations were also reported as being potentially restrictive to musical interpretation. Mismatched or absent synesthetic colours or tonal centres were reported as augmenting interpretative difficulties, as was the reliance on synaesthesia or AP as an interpretative framework.

Technical aspects of performance were identified as being influenced by synaesthesia and AP, however participant reports were highly individualistic. Both conditions were described as potentially enhancing instrumental technique, by providing possessors with an 'ideal' template, over which they could structure their practice. Adjusting instrumental techniques to ensure the produced sound 'matched' the synesthetic or AP template was acknowledged as improving practice efficiency and motivation. On the contrary, other participants acknowledged their condition impeded the development of technical aspects of their instrumental playing. Focussing attention on the concurrent synesthetic percepts to the detriment of instrumental technique was stated as being

disadvantageous. Furthermore, AP was reported as enhancing the facility and speed of music learning, thus diminishing the motivation to practice.

To conclude, all of the participants in this study who indicated their condition(s) hindered their ability to transpose reported this was due, either exclusively or predominantly, to their AP. These participants blamed the inflexibility and impeded development of their relative pitch (RP) ability as negative aspects of their AP. Participants with both conditions additionally reported that changes to perceived synesthetic percepts (such as colours) during a transposition task would reinforce the difficulty faced.

Playing a transposing instrument was correspondingly reported as often being either difficult or impossible, again with the majority of participants noting this was due to perceived differences in pitch between what was read on the score, and the sound produced by the transposing instrument. One synesthete participant reported mismatched synesthetic colours hindered her ability to play a transposing instrument, while participants with both conditions again noted the role of their synesthetic percepts in reinforcing the complications of the exercise.

Listening to, or performing in, a pitch system that differs from concert pitch was also frequently noted as being hindered by the possession of AP. Participants with AP noted the difficulty they faced when having to listen to music at baroque pitch, while also indicating that singing or playing music at both baroque and classical pitch was challenging.

6.4. Summary of Behaviour

As outlined in the introduction to this chapter, all participants (100%; n=35) noted a positive effect of their condition on at least one music-related task, while approximately three quarters of participants (74.3%; n=26) also reported at least one negative effect. Each individual participant gave details concerning any one, or combination of, affected tasks. Variations in the number of tasks, and the degree to which these tasks were either facilitated or hindered, were highly idiosyncratic. Furthermore, a substantially greater number of facilitated rather than hindered tasks were reported, with over twice as many tasks reported as being facilitated by the participants' conditions. In total, a greater number of participants indicated their conditions facilitated specific music-related tasks, with an even larger number of overall tasks reported as being aided by either or both conditions.

Synaesthesia and AP were reported as influencing participants' musical choices and preferences, leading to decisions relating to repertoire and concert programming, music listening and stylistic preferences, compositional choices, and instrument choices. Repertoire and concert programming decisions were reported as being made by synesthetes based directly on the synesthetic colour percepts induced by a particular piece or style, as well as by AP possessors based on the specific characteristic or mood of individual tonalities. Music listening preferences and aversions were similarly noted as being frequently determined by a participant's desire to engage with or avoid specific synesthetic percepts or tonal features of a particular work or musical style. Compositional choices were also reported as being influenced by these conditions, with decisions founded on synesthetic percepts or specific tonalities both enhancing and restricting the compositional process, while the

use of these conditions as a practical aid while composing was also noted. Furthermore, choice of instrument was reported as being influenced by the induced synesthetic percepts of participants with instrument sound→colour synaesthesia, leading to preferences or aversions to particular instrumental timbres.

Performance aspects of musical engagement, such as interpretation, technique, and transposition, were similarly noted as being affected by the possession of synaesthesia or AP. Musical interpretation was noted by both synesthetes and AP possessors as being either enhanced or restricted by their conditions. This was also the case with technical aspects of performance, where individual participants provided distinct examples of the enhancement or impediment of specific technical aspects of their playing, due to their condition(s). Unsurprisingly, AP was predominantly reported as negatively affecting various aspects of transposition, including written exercises, singing or playing while transposing, playing a transposing instrument, and listening to or performing at baroque or classical pitch. Synesthetic percepts were, however, reported as playing a role in reinforcing the difficulties faced by participants.

Overall, both engagement and avoidance behaviours were instigated by the materialisation or mismatch of synesthetic percepts or AP associations, specifically in relation to the choices, preferences, and performance aspects of musical engagement. Ultimately, however, the possession of synaesthesia or AP was reported as being overwhelmingly positive, with all of the participants in this study stating they considered the advantages of their condition(s) to far outweigh any potentially negative aspects.

When the results summarised in this current chapter are combined with those of the previous two results chapters (Chapter 4: 'Cognition', and Chapter 5: 'Affect'), they collectively outline and analyse the results obtained in response to the first research aim of this study: namely, to identify the degree to which the possession of synaesthesia or AP may facilitate or impair the cognitive, affective, and behavioural outcomes of musical development. The following results chapter (Chapter 7: 'Idiopathic Synaesthesia and Absolute Pitch: Interactions and Comparisons') outlines the results obtained in response to the second research aim of this study, which examines the potential interaction of both conditions.

Chapter 7

Synaesthesia and Absolute Pitch:

Interactions and Comparisons

The second research aim of this study is to investigate the potential interaction between synaesthesia and AP for musicians who possess both conditions. This results chapter is therefore dedicated to an examination of the interaction of both conditions, and a comparative phenomenological analysis of synaesthesia and AP.

The chapter is divided into two sections. First, the interaction of synaesthesia and AP will be discussed, by evaluating the dominance, interaction, and separability of synaesthesia and AP. Second, the phenomenological features of the inducers and concurrents of both conditions are outlined and compared. This comparison of the phenomenological features of these two conditions is provided given that to date, no systematic comparison has been undertaken.

7.1. Interaction of Synaesthesia and Absolute Pitch

"I would definitely link them [synaesthesia and AP]…I would associate a note with a colour. So, when I hear the melody, it's like painting a picture…I would definitely think they're quite connected."

Xavier (Synaesthesia and AP)

As mentioned in Chapter 2.3. ('Synaesthesia and absolute pitch research'), synaesthesia and AP have been anecdotally noted to frequently occur together, and there are recent studies demonstrating a genetic link between both conditions (Gregersen et al., 2013; Mottron et al., 2013). The interaction between these two conditions, however, has until now remained unstudied. Consequently, the analyses that follow evaluate the dominance, interaction, and separability of synaesthesia and AP for participants with both conditions.

Within this study, eleven participants (31.4% of total participant population) possessed both synaesthesia and AP (or QAP). Table 7.1 lists the 11 participants with both conditions, and records each participant's responses to four questions, concerning the dominance, interaction, and separability of synaesthesia and AP:

1. Which condition is more dominant?
2. How do they interact?
3. If you could switch off your synaesthesia, do you believe your AP would remain?
4. If you could switch off your AP, do you believe your synaesthesia would remain?

Table 7.1
List of 11 participants with both conditions and their responses to four key questions concerning the dominance, interaction, and separability of synaesthesia and AP

Participant	Dominant	Interaction	AP without SYN?	SYN without AP?
James	AP	SYN is reliant on AP	Yes	No
Mason	AP	Support each other	Unsure	Yes
Ella	AP	Support each other	Yes	Unsure
Xavier	AP/SYN	Support each other	Unsure	Unsure
Benjamin	AP	SYN is reliant on AP	Yes	No
Matilda	AP	SYN is reliant on AP	Yes	Unsure
Olivia	QAP	Support each other	Unsure	Unsure
Mia	QAP	Support each other	Yes	Unsure
Chloe	QAP	Support each other	Unsure	Unsure
Grace	QAP	Support each other	Yes	Unsure
*Samuel	AP	No interaction	Yes	Yes

Note. 'Synaesthesia' has been abbreviated to 'syn'. *Samuel is the only participant who does not have a music-induced type of synaesthesia.

Of the 11 participants, only one – Samuel – does not have a music related form of synaesthesia. He is the only participant to have indicated there is no interaction between his synaesthesia and his AP ability. He also explained that his AP was not reliant on his synaesthesia, and that both conditions occurred independently of each other. Because the following analysis investigates the interaction of synaesthesia and AP, and thus by its very nature is contingent on music-induced forms of synaesthesia, Samuel is excluded from the following discussion. The remaining ten participants with both conditions consist of six AP possessors and four QAP possessors. Due to the reasons outlined in Chapter 3.3.3.2.5. ('Scoring the absolute pitch test'), AP and QAP possessors are non-differentiated, and treated similarly, within the following analysis. The responses of these participants to the four questions stated above will be considered in the following section.

7.1.1. Synaesthesia and Absolute Pitch: The Question of Dominance

Of the ten participants with both conditions, nine asserted their AP ability was dominant. Reasons given for the dominance of AP over synaesthesia include AP's 'reliability', in contrast to synesthetic percepts, which are "subject to change". This perceived stability of AP is likely to be due to the categorical nature of AP associations, in contrast to the multidimensional and temporal nature of music-induced synesthetic percepts, where the secondary associations of several musical elements can be layered and evolve through time. Mia, for example, suggested that her QAP was the dominant condition, because her synaesthesia was "a bit less concrete and organised." In some cases, a further reason given for this perceived dominance is that synesthetic percepts developed after the establishment of AP. An extreme example of this was James, who developed colour associations for individual notes and tonalities in his late teens. James explained further that his instrument sound→colour associations had only recently started occurring and was oblivious to the reasons why these associations had begun to occur. James' unique case may be linked to his autism, as he declared: "I have a very strong feeling that my perfect pitch is linked to my autism because of the repetitive nature in which I develop memory, for example". It is possible that the tardive development of his synesthetic percepts may be profiting from the same mechanisms, due to the genetic overlap of these three conditions.

While the overwhelming majority of participants indicated a dominance of AP, one participant – Xavier – perceived both his synaesthesia and AP as equally dominant. To be able to label all of the notes of a musical passage, Xavier sings individual notes, either out loud (which is more effective), or in his head. Interestingly, he asserted his

AP is “not the strongest” yet obtained 100% on both piano and pure tones AP tests. He did, however, acknowledge that when tasked with labelling notes within a melodic passage, the perceived weakness of his AP might be a working memory, and not a pitch recognition problem. This interpretation would be consistent with his AP test results and justifies why he feels the need to “slow down” a passage, to enable him to subsequently distinguish the colour of each individual note as he is singing.

7.1.2. Synaesthesia and Absolute Pitch: The Question of Interaction

Within the group of ten participants with both conditions, three described their synesthetic percepts as being reliant on their AP ability, while seven expressed their conviction that synaesthesia and AP support each other in music-related tasks. Mason suggested: “In most cases, they will interact and the reason one is there is because the other is supporting it”, while Xavier indicated that for him “it's so hard to separate the two because one complements the other in my opinion.” When asked if he believed his AP ability and synaesthesia were linked, Xavier responded affirmatively:

> XAVIER: Yeah, I would definitely link them because after when people found out about or told me I had AP, I started to think about it over the years. And everyone's like, "How do you do it?" And when I would actually think about it, I would always be: yeah, I would associate a note with a colour. So, when I hear the melody, it's like painting a picture. So, you see the pitches and then you identify the notes from that. I would definitely think they're quite [pauses] connected [laughs].

Xavier provided a typically 'synesthetic' metaphor for his ability to identify and label notes, describing hearing a melody as "painting a picture". He followed this remark by describing how he "sees" the pitches, and from there is able to identify the notes.

Xavier furthermore indicated that while he does not experience grapheme→colour synaesthesia now, he does have memories of associating colours with letters (and not numbers) as a child. He situated the timeframe for this experience as occurring throughout primary school. What is interesting from a musical standpoint is that the colours that he remembers associating with the first seven letters of the alphabet (and still does, albeit diluted), are the same colours he associates with their corresponding musical notes: "I was learning the alphabet while I was starting music. Maybe it's that - it all connected for those few letters".

A similarly telling observation Xavier made is that it was at the end of primary school that he realised he experienced colours for individual tonalities. Xavier himself referred to this as a period of "transition". In his opinion, the colours he initially associated with letters were transferred onto his developing understanding of tonalities. Thus, due to his growing interest in, and understanding of, music, the transition from letter to musical note was forged. Xavier mentioned these colour associations were initially stronger on the piano than on the violin, as he describes the piano as "reinforcing the harmonies and the chords". While his earliest recollection of these colour percepts occurred mid to late primary school (9-10 years old), Xavier was unsure whether or not he experienced synesthetic percepts before this time; although his earliest memories are from this age, he acknowledged the possibility he has always associate colours with sounds.

The interaction of synaesthesia and QAP is underscored in the case of Mia, who only has reliable AP for 'white' notes (natural notes). It is these notes that induce stable synesthetic colours, and indeed Mia acknowledged not having synesthetic associations at all for the majority of 'black' notes (accidentals). This raises the question of the interaction between her synaesthesia and QAP. To be able to label accidentals, Mia will habitually need to 'bump' them up or down and compare them to her stronger natural notes.

Mia provided a second noteworthy example of the interaction of note→colour synaesthesia and pitch perception in the identification of notes within a chord: "I guess in the case of identifying notes in a chord, they might work together: I'd probably be able to immediately pick out the root of the chord in terms of AP…I might be able to pick out an individual note in the chord. But then I'd be able to figure out which chord it was more easily by virtue of the colours, textures and maybe what position. Then I'd probably go back to the AP and figure out the other notes in it." Mia exhibited a sense of difficulty untangling the exact role each condition plays within this process, yet what is clearly portrayed is an interweaving of both conditions within the same process. Mia remained uncertain, however, as to which condition 'came first', and whether her QAP abilities initially developed due to her colour associations, or whether the notes she had heightened pitch awareness for were assigned colours at a later stage of her musical development.

7.1.3. Synaesthesia and Absolute Pitch: The Question of Separability

Two questions regarding the separability of synesthetic percepts and AP were asked of participants with both conditions: whether their AP would remain without their synaesthesia, and conversely, whether their synaesthesia would remain without their AP (see Table 7.1 above). Absolute pitch was judged as being separable from synesthetic percepts by six of the participants, who indicated their pitch-labelling abilities would remain without possessing synaesthesia. The remaining four participants stated they were unsure if their AP would remain. For example, Mason admitted, "I still might, but I'm not entirely sure because it might be harder to have." Mason furthermore suggested that "part of the reason it [AP] is there is because of the assistance of the synaesthesia and the associations that make the perfect pitch possible," thus indicating his synesthetic percepts aid his AP ability. Overall, none of the participants were certain their AP would disappear at the cessation of their synesthetic percepts.

More divergence in responses was evident to questions concerning synaesthesia. Only one participant – Mason – was certain his synaesthesia would remain, regardless of the state of his AP possession. A further seven participants indicated they were unsure if their synaesthesia would remain after the potential loss of their AP, with Matilda suggesting her synaesthesia "would be diluted, I think. It would be less prominent. The colours would not be what they are at the moment." Two further participants stated their conviction that they would *not* have synaesthesia if it were not for their AP. It is noteworthy that both these participants – James and Benjamin – also have autism, and discussed the interaction of their autism, AP and synaesthesia within their personal interviews (for example, see Section 7.1.1.: 'Synaesthesia and absolute pitch: the question of dominance', above).

7.1.4. Summary of the Interaction of Synaesthesia and Absolute Pitch

Of the 35 participants in this study, 11 (31.4% of total participant population) possess both synaesthesia and AP (or QAP). Of these 11 participants, 10 possess at least one form of music-induced synaesthesia and were thus the object of this discussion on the interaction of both conditions.

Three aspects of the relationship between synaesthesia and AP were examined: the dominance, interaction, and separability of both conditions. Absolute pitch was overwhelmingly reported as being the dominant condition, with nine of the ten participants expressing this view. The reliability, stability, and chronologically earlier appearance of AP were given as reasons for this dominance. Only one participant stated that both conditions were equally dominant. When queried on the interaction of both conditions, seven participants reported their synaesthesia and AP support each other and work together in music-related tasks. The remaining three participants indicated their synesthetic percepts are reliant on their AP ability. Finally, two mirrored questions were asked of participants concerning the separability of both conditions. Six participants stated that their AP was not reliant on the corresponding colour percepts that are associated with each individual note, while the remaining four participants were unsure, indicating their synesthetic percepts aided their pitch-labelling ability. In comparison, when questioned on whether their synaesthesia would remain without their AP, seven participants stated they were unsure, and two participants indicated their belief they would not have synaesthesia. Only one participant acknowledged being certain his synaesthesia would remain, in the event of the loss of his AP.

7.2. Phenomenology of Inducers and Concurrents

"Every pitch has a different sound. [Pauses] It's almost like a different colour."

Emily (AP)

This following section provides a phenomenological comparison of the inducers and concurrents of synaesthesia and AP. When defining various types of synaesthesia, the term 'inducer' is used to describe the triggering stimulus, while the term 'concurrent' denotes the resultant synesthetic experience. In music→colour synaesthesia, for example, a musical stimulus is the inducer, while the resulting synesthetic colour percept is the concurrent. This terminology is not currently employed in the literature on AP. The results of this study nevertheless demonstrate the comparable nature of various facets of these two conditions. The terms 'inducer' and 'concurrent' are therefore employed here to correspondingly denote the sensory trigger and resulting experiential outcomes of the AP process.

7.2.1. Phenomenology of Inducers

An analysis of the various types of synesthetic inducers registered in this study is undertaken in this subsection. To enable a comparison between synesthetic inducers and AP inducers, changes to perceptual aspects of individual notes (such as timbre), which can affect an AP possessor's ability to label the given pitch, are also examined.

7.2.1.1. Synaesthesia inducers.

In this study, 35 different types of synaesthesia were reported as being experienced by participants (see Table 7.2). Participants were given descriptions of the different types of synaesthesia and were asked to select the types they believed they may experience. The selected types were discussed during the interview to confirm and validate, or deny, their self-reports. This subsection consequently examines the prevalence and features of the various inducers of these types of synaesthesia. In synaesthesia, ordinal over-learned sequences, such as the alphabet, time units, or numbers, are the most commonly observed inducers (Day, 2005; Novich, Cheng, & Eagleman, 2011; Shanon, 1982). Music also contains ordinal sequences, in the form of scales (as a sequence of notes used as an organising structure for music), and tonalities (as the relationship between the notes of a scale or key). As suggested by the results obtained from non-musical types of synaesthesia, the same trends in music-inducing forms of synaesthesia might be expected. The results of this study suggest this is the case, as the two most prevalent types of synaesthesia reported by participants were musical note→colour (n=14; 77.8% of synesthetes), and tonality→colour (n=13; 72.2% of synesthetes). Pure perceptual stimulation, such as taste, touch, or sounds, can also trigger synesthetic percepts, and again this was evident in the results, with instrument sound→colour (n=11; 61.1% of synesthetes) and musical sound→colour (n=11; 61.1% of synesthetes) being the most frequent examples (see Table 7.2).

Table 7.2

Prevalence of types of synaesthesia: list of the 35 types of synaesthesia reported by the 18 synesthete participants in this study

Type of Synaesthesia	**Frequency (n=18)**	**Percentage (%)**
Musical Note → Colour	14	77.8
Musical Key/Tonality → Colour	13	72.2
Musical Instrument Sound → Colour	11	61.1
Musical Sound → Colour	11	61.1
Grapheme → Colour	8	44.4
Time Units → Colour	6	33.3
General Sounds → Colour	5	27.8
Musical Notation (read on the score) → Colour	5	27.8
Emotion → Colour	4	22.2
Orgasm → Colour	3	16.7
Pain → Colour	3	16.7
Ticker-tape	3	16.7
Grapheme personification	2	11.1
Mirror Touch	2	11.1
Music Interval → Colour	2	11.1
Musical Sound → Spatial Coordinate	2	11.1
Personality → Colour (auras)	2	11.1
Spatial Sequence (number forms)	2	11.1
Emotion → Sound	1	5.6
Flavour → Colour	1	5.6
Grapheme → Vision	1	5.6
Kinetics → Sound	1	5.6
Lexeme → Flavour	1	5.6
Musical Instrument Sound → Flavour	1	5.6
Musical Key/Tonality → Flavour	1	5.6
Musical Notated Symbols → Colour	1	5.6
Musical Note → Flavour	1	5.6
Musical Note → Number	1	5.6
Musical Style → Colour	1	5.6
Musical Interval → Flavour	1	5.6
Non-Graphemic Ordinal Personification	1	5.6
Object Personification	1	5.6
Temperature → Colour	1	5.6
Vision → Smell	1	5.6
Vision → Sound	1	5.6

Note. The types are ordered by frequency (high to low). The percentage of total number of synesthetes in this study who reported experiencing a particular type of synaesthesia is provided in the right-hand column.

Overall, participants reported ten sound-inducing forms of synaesthesia, and these are tabulated below according to the two inducer categories noted above: ordinal sequences, and pure perceptual stimulation (see Table 7.3).

Table 7.3
List of the 10 types of sound-induced synaesthesia, with five types comprising ordinal sound sequences as inducer, and five types being induced by the perception of a non-ordinal sound stimulus

Ordinal Sound Sequences	**Pure Sound Perception**
Musical-note→colour	Instrument sound→colour
Tonality→colour	Musical Sound → Colour
Music Interval → Colour	General Sounds → Colour
Musical Note → Flavour	Musical Sound → Spatial Coordinate
Tonality → Flavour	Instrument Sound → Flavour

Participants therefore reported more individual *cases* of sequence-inducing synaesthesia, however the number of *types* of sound-related synaesthesia are evenly split between sequence and perceptual forms.

7.2.1.2. Absolute pitch inducers.

In AP, the inducer is systematically a discrete musical note, yet from a perceptual perspective this note can differ in multiple aspects, including exact pitch or timbre. For example, differences in pitch (such as baroque or classical pitch), or differences in the timbral quality of the instrument playing the note, can affect pitch recognition. During this study, an AP test battery was administered to participants who reported possessing AP. This test battery included two diagnostic tests: the first was comprised of 36 piano tones, while the second was comprised of 36 pure tones, thus incorporating notes of two different timbral qualities. The results of these two tests are shown in Table 7.4.

Table 7.4
Results of the two AP diagnostic tests (piano tones and pure tones) administered to participants in this study

Condition	Piano Tones: Mean average (out of 36)	Pure Tones: Mean average (out of 36)
AP (n=22)	35.2 (97.8%)	30.5 (84.7%)
QAP (n=6)	13.2 (36.7%)	10.5 (29.2%)
TOTAL (n=28)	24.2 (67.2%)	20.5 (56.9%)

Note. Mean average scores out of 36, and percentage of correct responses, are given for both tests.

Participants obtained superior scores when tested with piano tones as opposed to pure tones, with a total decrease of 10.3% in mean average score attained. Thus, individual pitch-labelling ability is contingent on specific factors relating to the inducer, including the timbre of the perceived note.

7.2.2. Phenomenology of Concurrents

The following section examines and compares the phenomenology of the concurrents of synaesthesia and AP, first, through an analysis of the prevalence of synesthetic concurrents reported by synesthetes, and second, through reports from AP possessors detailing three types of secondary associations that were present during the pitch-labelling process. In addition, cases of individual notes inducing personality or characteristic, visual, or tactile concurrents are presented and considered.

7.2.2.1. Synaesthesia concurrents.

Synesthetic concurrents can occur in any sense modality, yet typically involve visual percepts, with colour being the most commonly experienced synesthetic concurrent across all types of synaesthesia (Simner, Mulvenna, et al., 2006). The 18 synesthete

participants collectively reported possessing 35 different types of synaesthesia, and colour is analogously the most prevalent concurrent overall. Indeed, colour is the concurrent in the top 11 most frequent of the 35 types of synaesthesia (see Table 7.2 above). Colour occurs in 17 of the 35 types of synaesthesia (48.6% of types), and of these 17 types, 9 were sound-induced (52.9%).

Both music and non-music related types of synaesthesia were reported with music-related types falling into two categories: types where sound (including music) is the *inducer* (n=15; 83.3%), and types where sound is the *concurrent* (n=3; 16.7%). Sound is therefore overwhelmingly an inducer in the sound-related forms of synaesthesia documented in this study. There are therefore 18 forms that incorporate sound, leaving 17 that are non-sound related. Of the 15 sound-induced forms of synaesthesia, the reported concurrents consist of colour (60%; n=9), flavour (26.6%; n=4), number (6.7%; n=1), and spatial coordinate (6.7%; n=1). Colour is therefore overwhelmingly the most prevalent concurrent within the sound-induced forms of synaesthesia, accounting for 60% of all concurrent types (see Figure 7.1).

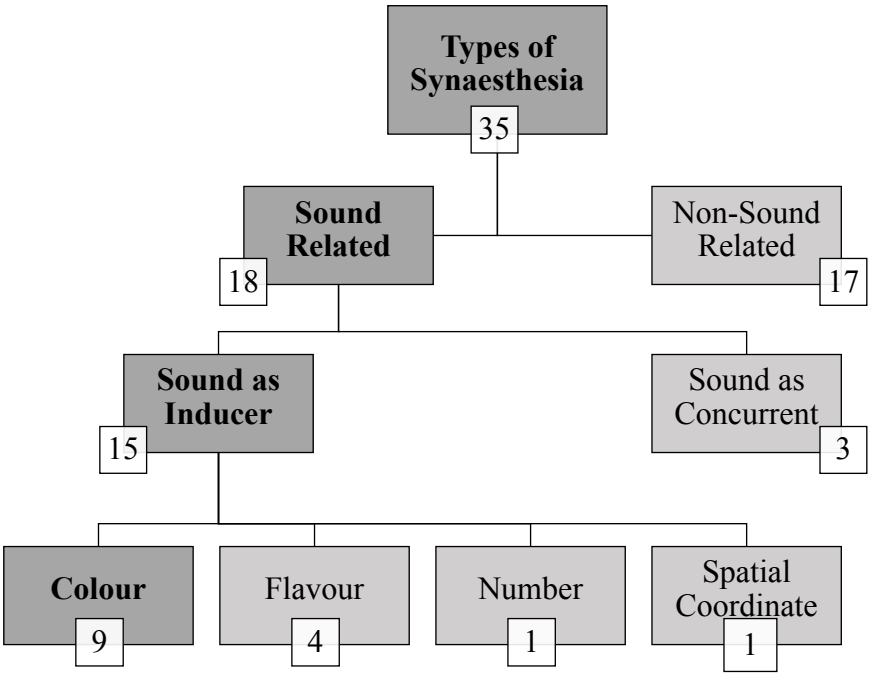

Figure 7.1. Diagram showing the number of reported types of concurrent in sound-induced forms of synaesthesia. Colour is the most frequently reported concurrent (60%; n=9).

A clear representation of the dominance of colour as a concurrent is evident when the number and percentage of overall cases of specific concurrents is tabulated (see Table 7.5).

Table 7.5
The number of overall cases of each type of concurrent, for all of the reported types of synaesthesia

Number of Overall Cases	Percentage	Type of Concurrent
91	79.1	Colour
5	4.3	Visual modality
5	4.3	Flavour
4	3.5	Spatial coordinate
4	3.5	Personification
3	2.6	Sound
2	1.8	Tactile
1	0.9	Smell
Total Cases: 115	**100%**	**Total Concurrent Types: 8**

Colour is therefore the concurrent in 79.1% of overall cases of synaesthesia reported in this study. As can be seen in both Tables 7.5 (above) and 7.6 (below), sensory concurrents - visual, gustatory, auditory, tactile, and olfactive - span all five senses, while two further categories – spatial coordinate and personification – are also included. Table 7.6 lists the 35 types of synaesthesia by concurrent type, with the concurrents ordered by prevalence (high to low).

Table 7.6
A tabulation of the 35 types of synaesthesia by concurrent type

Type of Concurrent	Type of Synaesthesia	Frequency (n=18)	Percentage (%)
COLOUR	Musical Note → Colour	14	77.8
	Musical Key/Tonality → Colour	13	72.2
	Musical Instrument Sound → Colour	11	61.1
	Musical Sound → Colour	11	61.1
	Grapheme → Colour	8	44.4
	Time Units → Colour	6	33.3
	General Sounds → Colour	5	27.8
	Musical Notation (read) → Colour	5	27.8
	Emotion → Colour	4	22.2
	Orgasm → Colour	3	16.7
	Pain → Colour	3	16.7
	Music Interval → Colour	2	11.1
	Personality → Colour (auras)	2	11.1
	Flavour → Colour	1	5.6
	Musical Notated Symbols → Colour	1	5.6
	Musical Style → Colour	1	5.6
	Temperature → Colour	1	5.6
VISUAL MODALITY	Ticker-tape	3	16.7
	Grapheme → Vision	1	5.6
	Musical Note → Number	1	5.6
FLAVOUR	Lexeme → Flavour	1	5.6
	Musical Instrument Sound → Flavour	1	5.6
	Musical Key/Tonality → Flavour	1	5.6
	Musical Note → Flavour	1	5.6
	Musical Interval → Flavour	1	5.6
SPATIAL COORDINATE	Musical Sound → Spatial Coordinate	2	11.1
	Spatial Sequence (number forms)	2	11.1
PERSONIFICATION	Grapheme personification	2	11.1
	Non-Graphemic Ordinal Personification	1	5.6
	Object Personification	1	5.6
SOUND	Emotion → Sound	1	5.6
	Kinetics → Sound	1	5.6
	Vision → Sound	1	5.6
TACTILE	Mirror Touch	2	11.1
SMELL	Vision → Smell	1	5.6

Note. The concurrent types are ordered by prevalence (high to low). Each type of synaesthesia within each concurrent type is ordered by frequency (high to low), including overall percentage (n=18).

7.2.2.2. Absolute pitch concurrents.

It is generally assumed that for people with AP, the auditory perception of a given pitch will engender a verbal representation (graphemic pitch label, most commonly alphabetic). Thus, an involuntary and stable mapping between the initial exposure to a perceptual auditory inducer (given pitch) and a verbal representation (pitch label) occurs. Discussion with the 28 AP or QAP possessors in this study, however, revealed this assumption to be a deficient and inaccurate representation of the pitch-labelling process. In Chapter 4.1.2.5. ('Sound bank and absolute pitch development'), the use of a sound bank for pitch-labelling and memorisation was considered. This auditory→auditory coupling was demonstrated to play an important role in the pitch-labelling process for certain AP possessors. One additional recurring theme underscored by AP possessors during the interview process was the notion of individual notes sounding, in the words of James, "exclusively different from the other 11 in the octave", and "much like being able to depict different sounds or different voices from each other." Absolute and quasi-absolute pitch possessors were therefore asked to describe the process with which they were able to label individual notes.

Of the 28 AP and QAP possessors in this study, three failed to mention secondary associations present in their pitch-labelling process, thus indicating the process was entirely automatic (i.e. note→label). The remaining 25 AP/QAP possessors (89.3% of the total number of AP/QAP possessors) indicated that at least one secondary association is included as a fundamental aspect of their pitch-labelling process. Of these 25 participants, two reported that the only addition to their pitch-labelling

process is to error check their responses against either a more memorable note, or by using an internal sound bank (as discussed in Chapter 4.1.2.5.). This left 23 participants (82.1% of AP/QAP possessors) who indicated that at least one further extra-sensory association is operative during their pitch-labelling process, falling within personal characteristic, visual, and tactile categories. It appears, therefore, that the general assumption of an automatic, one-step pitch-labelling process, is inadequate. In order to present a clearer understanding of this process, an overview of the types of associations (or *concurrents*) described by AP possessors is undertaken. Three types of concurrents were reported as being potentially operative during the pitch-labelling process: 'personality or characteristic', 'visual', and 'tactile' concurrents. These three concurrent types are examined in the following subsection.

7.2.2.2.1. Note characteristic or personification as concurrent.

Of the 23 AP/QAP possessors who indicated experiencing at least one extra-sensory association, 13 (56.5%) reported perceiving individual notes or tonalities as having distinct personalities or specific characteristics. Within this group, numerous characteristics were mentioned. These include note personification (whereby individual notes have distinct personalities, potentially including gender), character types, colour (non-synesthetic), texture (non-tactile), temperature (non-tactile), and emotion (discrete emotional aspects). These characteristics were also regularly applied to tonalities as well as individual notes. Examples of these personality or characteristic representations are examined in this section.

While only possessing AP, Emily depicted each pitch as having a different musical "colour". She reported finding it difficult to describe these associated 'colours' or 'feelings', affirming:

> EMILY: Every pitch has a different sound. [Pauses] It's almost like a different colour… I don't really know how to describe it but with certain notes, I feel like there's a different feel to it. B flat and F and F sharp have a kind of [laughs] - they all just feel different. They have a distinctive feeling about them… don't really know how to describe them. It's weird.

Emily indicated that tonalities are comparably allocated individual characteristics: "The A major chord: the sound is much warmer than G major…I don't quite like F major because it's a little bit boring [laughs]. D is quite calming…C major - [pauses] is happy." The distinguishing characteristics of individual notes and tonalities are fundamental to Emily's ability to label them. In a similar fashion, Sophie described individual notes as having a unique texture, character, and warmth. When asked how she was able to distinguish individual notes, she responded:

> SOPHIE: Mmmm it's the texture, I guess. [Pauses] Yeah, I think all the notes have different textures. The black keys have their own character and it's a bit cooler than the white keys. And between tones and tones the gaps are even bigger. That's why I'll be able to recognise them, although I don't see the colours. It's just the texture and maybe the warmth of each note.

Sophie described black keys as being ‘cooler’ than white keys yet did concede she would be unable to verbally describe the exact characteristics of each individual note. Compare this statement to that made by Chloe, who has both QAP and various forms of synaesthesia:

> CHLOE: I don't see the colour red or the colour green. They're a kind of blended hue of colours that sort of exist, especially crossovers between different colours…Those colours that I see are like auras of colour. They're not the colour but they're blended auras of other colours…I have tried to pin them down…They're not extremes. I can give a range: warm colours; cooler colours.

The characteristics described by Emily and Sophie therefore appear to be felt or perceived but remain indescribable. Far from refuting the potential for personality or characteristic concurrents in AP perception, however, this insistence on the idiosyncratic features of individual notes is analogous to forms of associative synaesthesia, where the concurrents are known, but not seen.

Chloe, who has both synaesthesia and QAP, not only described individual notes as having unique characteristics, but also personalities and genders. While certain notes are more suited to a specific gender, she does not believe that they are exclusively one or the other. These personalities are more of a “gut feeling” for her than a truly describable list of characteristics. She furthermore asserted that they are linked to the synesthetic “phantom shades” she sees when hearing music in her mind. As a composer, Chloe indicated that these idiosyncratic characteristics render different

notes or tonalities more suitable for specific compositional applications, depending on the mood or affect she is trying to achieve.

In general, within this group of AP possessors, numerous characteristics were mentioned. These include note personification (whereby individual notes have distinct personalities, potentially including gender), character types, colour (non-synesthetic), texture (non-tactile), temperature (non-tactile), and emotion (discrete emotional aspects). These characteristics were also regularly applied to tonalities as well as individual notes. Further examples of note or tonality characteristics, as reported by all 13 possessors, are presented in Appendix J.

7.2.2.2.2. Visual concurrent.

Of the 23 AP/QAP possessors who indicated at least one extra-sensory association, eight (34.8%) described visualising a keyboard. Within this group of eight, four possessors also indicated visualising notes on a stave or score under certain conditions. As images of a stave or score were systematically noted as being sporadic, uncommon, and lacking in vividness, this section focuses on reported examples of visual keyboard representations.

Besides the complex visual imagery (CVI) noted in Chapter 4.2.2.2.2.2. ('Case study 5: Lucas'), Lucas depicted a second synaesthesia-like manifestation of AP, with a keyboard image being used as an associative tool for labelling heard notes. This keyboard image resembles spatial-sequence synaesthesia, where individual notes are situated within his interior visual space in a predetermined position along the keyboard, from left to right. For Lucas, this visualisation is a simple one-octave

representation of the keys. When asked what occurred to his visualised keyboard when perceiving a note, Lucas indicated that he can "see a slight change in colour or something on my mental image of the keyboard". The heard tone is thus translated onto the image, with the corresponding key being "pressed" on his visual keyboard. Lucas discussed the importance the spatial location of each individual note plays in his ability to label the note, and although the reference to a "change in colour" was metaphorical, it was accompanied by his insistence that he sees the heard note "being pressed", thus indicating a perceived change in the visual aspect of individual keyboard keys situated along his mental image.

When prompted to label a note, Lucas instantly visualises a piano keyboard. This is not the case when asked to produce a note, but only to label one (see Chapter 4.1.2.5.2.: 'Lucas'). Indeed, the influence of both visual and auditory imagery was observed in his ability to provide labels for, and produce, accurate pitch representations. Of interest here is the use of two different (but interior) memorisation strategies to both *identify* and *produce* specific pitches. The image – almost photographic – of a keyboard is used as a tool to identify pitches (visual imagery), and a sound bank of familiar songs and pieces is used as a mnemonic tool to produce pitches (auditory imagery). Both of these forms of imagery rely on the strength, vividness, and stability of the memory of the image. As such, both his visual representation of the keyboard, and his memory bank of auditory representations of specific pitches (as embedded in known songs and pieces), rely on vivid and stable mappings. This underscores a clear similarity to synesthetic concepts.

Lucas does provide one example where the *production* of a pitch is linked to a visual image of a keyboard:

> LUCAS: I remember - for my audition for the Trinity College Choir, so the end of Year 12: 2011 - that was one of my tests, being able to identify chord tones. Actually, no it wasn't. It was an interval. He played a B flat on the piano and he asked me to sing a perfect fourth below it. I did the math in my head, visualised the keyboard and went down to what I knew was an F. Then I hummed the F in my head, then produced it. I didn't actually use the interval. … Because my knowledge of theory is quite limited, if I was played a D flat major triad or something, then it may take me a bit longer to identify the chord tones because I don't know my scales or I don't know key signatures.

In this specific example visualisation was incorporated into a broader, chaotic strategy. Instead of pitching the interval as instructed (using relative pitch), Lucas followed the path of mathematically calculating the note he was meant to sing, visualising a keyboard (VI), finding the note needed, humming the note in his mind (AI), and then producing the note exteriorly. The process therefore included elements of mental calculation, and both visual and auditory imagery. It is worth noting however, that this example occurred before Lucas began tertiary education, and as such was at a time when his theoretical skills were still very basic. This further accentuates Lucas's admission that before entering the Conservatorium his relative pitch abilities were deficient, in contrast to pitch sensitivity, which was already present.

In contrast to the one-octave image of Lucas, Joshua visually perceives notes on a multi-octave keyboard image. Joshua not only mentioned that individual pitches have specific tonal colours or “resonance”, but also described them as having a “spatial” quality and falling along a scale, the location of each individual note being register-specific: “By "the scale" I mean the seven, eight, nine octaves of human pitch perception, basically. Or the six or seven octaves that are musically usable of that range.” This imagery is automatic and involuntary, and as well as “instinctive”. This register-specificity differentiates his imagery with that of other participants: Joshua insisted on the importance of register in both his pitch-labelling ability and keyboard imagery, whereas the keyboard imagery noted previously by other participants was systematically of only one octave of the keyboard. This is not an inconsequential difference, as this “spectrum of pitches” is fundamental to Joshua’s note labelling ability, as he asserted he does not “think of individual pitches in isolation”, but rather is aware of not just of the resonance of the note, but “of other pitches around it that have closer or more distant harmonic relations to it. If I think about what makes D different from E flat, they do have a different colour, but that colour comes from a different place in the scale”. Thus, this sequential imagery not only aids Joshua’s pitch identification, it also provides him with a rich tone colour palate, where both pitch and register juxtapose to create the unique “resonance” Joshua mentioned he associates with each note. For Joshua therefore, musical notes have both a unique ‘colour’ and ‘spatial location’, situated along a keyboard.

The visualisation of a keyboard does not always occur in isolation from other extra-sensory associations. Coupled with this visual keyboard image, Benjamin affirmed he is able to feel the piano keys under his fingers when listening to music, interpreting

this sensation as “with the bump for that black key and then it would go down and I'd have to cross that finger over etcetera”. These visual-tactile sensations occur while listening to any music, not just keyboard repertoire. The keyboard image is therefore a stable pitch-identification reference, regardless of repertoire or sound source. In addition, Benjamin does not need to know the music well to have these experiences, as they can occur at the first hearing of a new piece. Furthermore, Benjamin described commonly visualising a score when improvising: “…when I'm improvising…the tactile sensation in combination with that visual thing is very strong. It's like walking over a landscape and feeling the hills and valleys under your hands. I know what it feels like to go over that mountain of that F sharp or whatever. That's coming up. And I will be seeing it at the same time.” Benjamin’s assertion of the interplay between the auditory, visual, tactile, and even kinaesthetic memories of music is striking: “If I'm memorising at the piano, it will always be to do with: it's in this key; it feels like this; this is how it feels in my body. It couldn’t be any other key, it's just that: that's its personality.” The multimodal, and multisensory, template he uses to memorise music is an ongoing theme in discussions with Benjamin, as summarised in the preceding examples. A further, dynamic example of the tactile representation of pitch will be discussed in the following section (Section 7.2.2.2.3.: ‘Tactile concurrent’).

In this study, keyboard visualisation was not reported exclusively by pianists. While being a cellist, Ava indicated visualising a keyboard, and not the fingerboard of her cello. Ava’s first instrument was, however, the piano, and this imagery is thus coherent with her initial exposure to individual notes. As a singer, Lucas is a further example of a non-pianist reporting a visual keyboard representation of pitch. He was, however, taught piano for a very limited amount of time during adolescence, and

piano was therefore the object of his initial *instrumental* experience. Consequently, all eight participants who indicated visualising a keyboard noted piano as the initial instrument of their formal musical training, even if it is no longer their primary instrument, or indeed an instrument they continue to play. In contrast, Noah indicated visualising a fretboard as one component of his pitch-labelling process (see Chapter 4.1.2.5.1.: 'Noah'). Noah's first instrument was the electric bass, and this is the instrument – along with guitar – that he currently plays. The visualisation of an ordinal scalic representation of notes therefore appears to be contingent on the type of early instrumental exposure provided.

7.2.2.2.3. Tactile concurrent.

Of the 23 AP/QAP possessors who indicated at least one extra-sensory association, six (26.1%) reported physically sensing individual notes. Of these six, four described internally singing the heard note back to themselves in order to label it, with this internal singing engendering a physical sensation within the laryngeal region. Only two AP possessors (8.7%), reported a tactile sensation when hearing individual notes. The case of Benjamin was described in the previous section on visual concurrents, and this section therefore focuses on the case study of the violinist Liam, who reported feeling individual notes on the tips of his fingers.

As a violinist, Liam described individual notes as including textural elements based on where they sit, in first position on the violin. This textural element is not only descriptive, but also informs his preference for certain notes. Liam outlined two categories of notes: sharp or pointy notes, and round notes. This categorisation was initially based on the visual representation of the notes in the treble stave. Within the

range of first position on the violin (from G below middle C to high B, fourth finger on the E string), notes that are bisected by one of the lines of the stave are deemed "pointy", while notes that fall between two lines are "round". This template corresponds to specific fingering, whereby all bisected notes are played by either the first or third finger, while all notes that sit on or under a line are either open strings, or played by the second or fourth finger: "Back to the violin, the first and third fingers are pointy because, in the violinistic sense of learning first position, the one and three are on lines; two and four are - in first position - round notes in between the lines." For Liam, the first and third fingers are therefore by correspondence "sharp", while the second and fourth fingers are "round".

What is noteworthy is that the physical expression of the note is more important than the pitch label of the note; as such, an F above middle C (second finger, D string) will be round, whereas an F one octave higher (first finger, E string) will be pointy. This classification system does not only operate for notes produced by the violin, however, as Liam transfers this same system to notes played by any instrument. Correspondingly, an F above middle C will be round, regardless of which instrument produces it. This *classification* system subsequently translates into a *preferential* system intimately linked to the two categories of notes outlined above, where the textural quality of the note predicts its appeal. Hence, Liam finds himself drawn to round notes, which are "more inviting…more comforting, more wholesome, more endearing", whereas sharp or pointy notes "feel less inviting". Liam asserted he feels more "aesthetically pleased" by round notes – a roundness that he again draws into the visual realm, by connecting this to the image of the note sitting between two lines,

undisrupted, and therefore more stable than its counterpart, the bisected pointy note (see Figure 7.2).

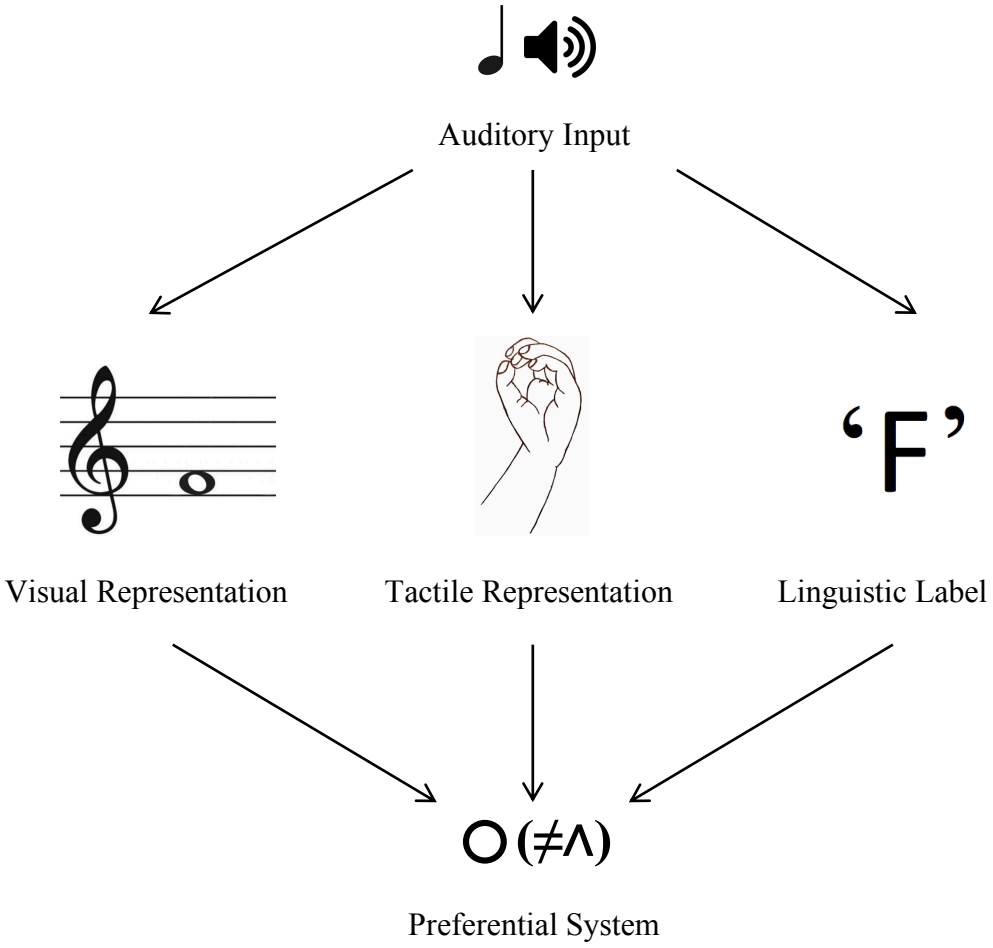

Figure 7.2. The multisensory representational system of Liam's absolute pitch (AP): Auditory input (pitched sound) induces a visual representation (note on stave), tactile representation (sensation on finger tips), and a linguistic label (learnt pitch label). These representations evoke a corresponding preferential system for 'round' vs. 'pointy' notes. This preferential system is based on the visual representation of notes on the stave (in treble clef) and is subsequently transferred to tactile preferences (preferred fingers), and auditory preferences (for notes played on any instrument).

When hearing a pitched sound, Liam indicated he involuntarily taps or presses down the corresponding finger of the note heard. Furthermore, when he shifts position, and plays higher up the fingerboard, he transfers the notion of his first and third fingers being 'pointy', and his second and fourth fingers being 'round', regardless of what notes these fingers are playing. Liam emphasised that playing what he would consider

as a ‘round’ note in first position with a ‘pointy’ finger in another position higher up the fingerboard, would feel less comfortable for him than playing the same ‘round’ note with another ‘round’ finger (and vice versa). These immediate and unintentional reactions and sensitivities strengthen the importance of the diverse correspondences that function together in the one ability.

Overall, two AP possessors indicated experiencing tactile sensations on their fingertips when processing individual notes. As a pianist, Benjamin translated this sensation as feeling the bumps and ridges of the notes of the keyboard while listening to music. His AP enables this correspondence to be an automatic and stable representation of the music he was hearing, as it occurs regardless of either the instrument producing the given music, or his familiarisation with it.

For Liam, the auditory input of each individual note was initially translated into a visual representation of the note on the stave. As a violinist, this imagery was followed by a tactile sensation on the tip of the corresponding finger that would play that note in first-position on the violin. This tactile sensation was therefore register-specific, and not determined by the pitch label per se. These visual and tactile associations consequently inform both tactile and auditory preferential systems, whereby Liam reported experiencing greater comfort playing notes with fingers that ‘match’ the visual representation of the corresponding note, and where he indicated a preference for notes that are not visually bisected but situated in between the lines of the stave. These notes are accorded personal descriptors, such as inviting, comforting, wholesome, and endearing.

Both examples of the tactile representations of pitch depicted above include elements of visual imagery (VI): keyboard visualisation and synesthetic percepts in the case of Benjamin, and stave visualisation in the case of Liam.

7.2.3. Summary of the Phenomenology of Inducers and Concurrents

In this section, the phenomenological features of the inducers and concurrents of synaesthesia and AP were outlined and compared.

In total, 35 different types of synaesthesia were reported as being experienced by participants in this study, with the most prevalent types being musical note→colour and tonality→colour synaesthesia: two forms of ordinal musical sequences. Pure perceptual auditory stimulation was also reported as inducing synesthetic percepts, with the most prevalent examples being instrument sound→colour and musical sound→colour synaesthesia. Of the 35 types of synaesthesia reported in this study, ten types have sound as the inducer: five with an ordinal sequence inducer, and five with a pure auditory inducer.

While the inducer in AP perception is systematically a discrete musical note, differences in timbre were established as affecting pitch-labelling abilities. The 28 AP and QAP participants in this study collectively performed at a superior level on the piano tones task of the AP test, as opposed to the pure tones task. Specific aspects of the inducing musical note can therefore affect pitch-labelling ability for AP possessors.

Statements from the 18 synesthete participants in this study revealed that the most prevalent synesthetic concurrent is colour, for both sound induced, and non-sound induced forms of synaesthesia. Overall, however, concurrents listed in this study span all five senses, and also include spatial coordinates and note or tonality personification.

Absolute pitch possessors in this study described four types of concurrent present during the pitch-labelling process: auditory, characteristic or personality, visual, and tactile. The auditory→auditory association of the opening, or most prominent notes of familiar songs or pieces, was previously examined in relation to the development of a 'sound bank' (see Chapter 4.1.2.5.: 'Sound bank and absolute pitch development'). The depiction of personal characteristics included note personification (including gender), as well as discrete characteristics such as colour, texture, temperature, and emotion. Within the visual modality, the most frequently reported image was of a keyboard. Finally, one pianist and one violinist recounted feeling tactile sensations on their fingertips when listening to music, while physical sensations within the laryngeal region were also reported.

While the above-mentioned secondary associations were described as being automatic and involuntary, AP possessors in this study commonly reported a tapering off of the strength of these associations over time. For example, Lucas, Joshua, Ava, and Sienna acknowledged experiencing the visualisation of a keyboard during their childhood/adolescence (in the period of the development of their pitch-labelling abilities) as a tool to learn the labels of pitch frequencies, for which they had a strong prior sensitivity. Concurrents were reported as being more automatic and vivid during

this period, with all four conceding this automaticity declined once sufficient exposure to the learnt component (pitch label) was achieved. They are now consequently less reliant on these secondary associations, as their AP ability has become more robust, and they have a stronger familiarity with the notes. It therefore appears that the considerable acceleration with which labelling occurred enabled the concurrent to be eventually bypassed (see Figures 7.3a and 7.3b). The associations are, however, acknowledged as being ever-present, stable, and available, but less perceptually salient.

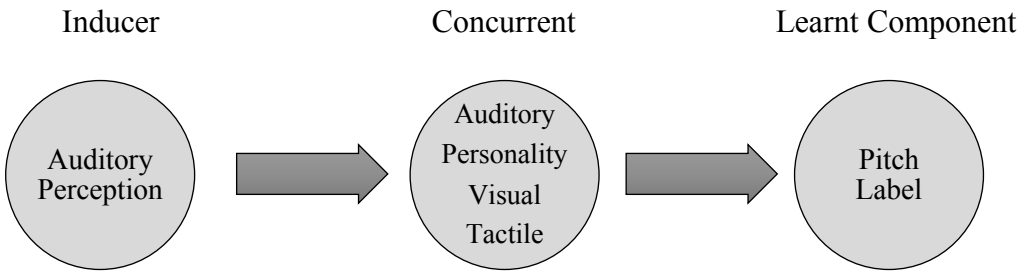

Figure 7.3a. Absolute pitch development during childhood or adolescence. This typically follows a developmental trajectory of an initial association between the individual note as inducer, and a concurrent association in a secondary sense or sense modality. This inducer→concurrent pair is subsequently assigned a graphemic label during musical training, thus further acquiring a learnt ordinal component.

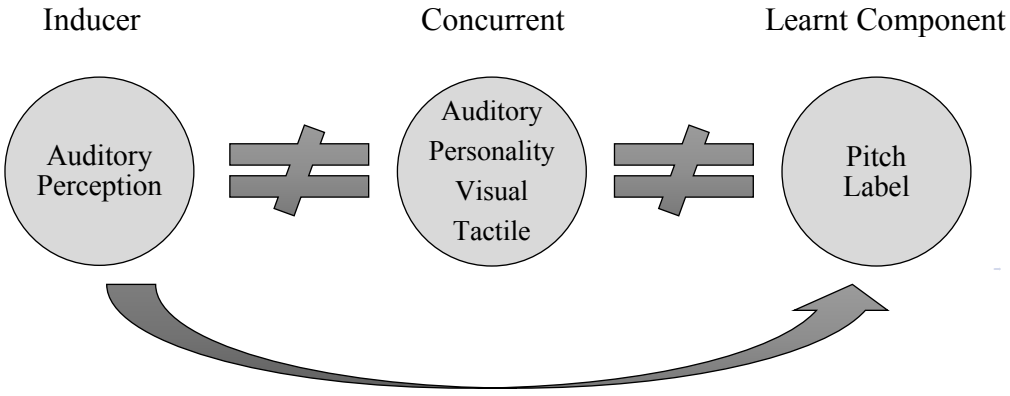

Figure 7.3b. Bypassing of concurrent. Once sufficient exposure to the learnt component (pitch label) was achieved, the speed of the two stages of the pitch-labelling process increased sufficiently to enable the necessity of consciously attending to the concurrent to be bypassed.

In summary, synaesthesia and AP are two neurological conditions that share phenomenological similarities in both inducers and concurrents. An analysis of the descriptions provided by synesthetes and AP possessors in this study ascertained that the phenomenology of synaesthesia and AP, particularly in relation to the concurrents induced by both conditions, contain strikingly similar elements, and are in many cases identical.

7.3. Summary of Synaesthesia and Absolute Pitch: Interactions and Comparisons

The second key research question of this study is to investigate the potential interaction between synaesthesia and AP, in participants with both conditions. This chapter therefore examined the dominance, interaction, and separability of synaesthesia and AP, as well as compared the phenomenological features of the inducers and concurrents of both conditions.

Eleven participants in this study were diagnosed as possessing synaesthesia and AP (or QAP). Given the rarity of both conditions, this number is in itself noteworthy, as it accounts for 31.4% of the total participant group. Of these 11 participants, 10 have at least one form of music-induced synaesthesia and were thus retained for inclusion in this chapter. While AP was habitually reported as being the dominant condition in music-related tasks, both conditions were frequently described as working together. The question of the separability of the conditions was a difficult one for many participants to answer, both because of their inability to recall the chronological evolution of their conditions, and also because of their coexistence in the everyday musical lives of participants.

From a phenomenological perspective, the comparison of synaesthesia and AP revealed a striking number of similarities. This was particularly evident when comparing the concurrents of both conditions. The majority of AP possessors acknowledged that individual musical notes systematically induce secondary multisensory or multimodal associations, including auditory, personality characteristic, visual, and tactile percepts. Indeed, statements from AP possessors concerning the resulting experiential outcomes of the pitch labelling process defined these concurrents as automatic, involuntary, and stable. While in many cases the associations are complex in nature, they bear a striking resemblance to the synesthetic concurrents reported by synesthetes in this study. The following chapter (Chapter 8: 'Discussion') examines this relationship more closely, after initially discussing the results outlined in the previous three results chapters: Chapter 4 ('Cognition'), Chapter 5 ('Affect'), and Chapter 6 ('Behaviour').

Chapter 8

Discussion

This study examined the degree to which synaesthesia or absolute pitch (AP) possession may facilitate or impair the cognitive, affective, and behavioural outcomes of musical development, and potential interactions between both conditions.

The major conclusion drawn from the literature review was that the relationship between certain types of sound-related synaesthesia and AP is frequently noted, but that any interaction between these two conditions remains highly speculative and lacking empirical foundation. Furthermore, the classification of different types of synaesthesia, and characteristics and diagnostic criteria of both conditions, is less than straightforward, precisely because the diagnostic criteria for each condition are ambiguous. In the case of synaesthesia, previous studies have noted that the term signifies and-describes different notions, realities, and perspectives, and is therefore highly context-specific. Similar inconsistencies in explanations concerning AP were also noted, with definitional irregularities focussing on whether this is as an all-or-nothing condition, or whether it lies along a continuum. In line with research by Wilson and colleagues (2009), an amended traditional view of AP classification was adopted in this study, with participants categorised as either AP or quasi-AP (QAP) possessors. Although weaker, QAP is regarded as a form of AP, and is thus treated equally within the discussion of the results. Additionally, as noted in the literature review, previous difficulties in assessing the prevalence of both conditions have

largely been due to the above-mentioned inconsistencies of diagnostic and definitional criteria. Both conditions, however, are generally accepted as rare, with synaesthesia accounting for less than 5% (Simner, Mulvenna, et al., 2006) and AP less than 0.01% (Profita & Bidder, 1988) of the general population.

One key difference in the scope of literature pertaining to synaesthesia and AP concerns their influence on specific musical abilities, or musical expertise. While general studies on the relationship between synaesthesia and creativity have been conducted, the literature review revealed that no studies to date have specifically investigated the influence of synaesthesia on musical abilities, expertise, or development. In contrast, several comprehensive studies have explored the impact of AP on specific musical abilities, including pitch memory, melodic dictation, interval identification, and relative pitch (RP) processing (see Chapter 2.2.6.: 'Absolute pitch and musical ability').

The literature review outlined a major lack of research into the music-related benefits or disadvantages of synaesthesia possession. Furthermore, a comparative analysis of the current literature on synaesthesia and AP uncovered substantial differences in how these two conditions are treated. While synaesthesia is systematically labelled as a neurological condition, AP is customarily labelled as an exceptional ability or savant skill. Synesthetes are widely assumed to be 'born with it'; in contrast, the significance of genetic versus environmental factors in enabling the 'acquisition' of AP remains the focus of much AP research.

The co-occurrence of synaesthesia and AP has been anecdotally noted in case studies of professional musicians. More specifically, five recent articles addressing the relationship between synaesthesia and AP from behavioural, neurological, and genetic perspectives were reported in the literature review (Chapter 2.3.: 'Synaesthesia and absolute pitch research'). In reviewing the literature, however, no data was found on the association between synaesthesia and AP in music performance or consumption contexts: an omission that is addressed by the present study.

8.1. Summary of the Key Findings

This study revolves around two central questions concerning the impact of synaesthesia and AP on musical development, and the potential interaction of these two conditions. The findings of this study are based on data collected through an online questionnaire, semi-structured lived-world interviews, and synaesthesia and AP battery tests. Results obtained from the online questionnaire were used to inform the development of the interview template, while the synaesthesia and AP tests were undertaken primarily as diagnostic tools. In total, thirty-five student and staff participants were recruited from the Melbourne Conservatorium of Music, at the University of Melbourne, Australia. This faculty has the largest and most comprehensive tertiary music program in Australia, with a highly skilled and distinguished student and staff population.

The results outlined in the previous four chapters concerning the cognitive, affective, and behavioural outcomes of the possession of synaesthesia and AP, and a comparison of the two conditions, draw heavily from data collected through participant interviews. The richness of the data provided in these one-on-one

interviews was unexpected, with participants offering far more detailed and focused comments than had been initially anticipated. Indeed, interviews typically lasted well beyond the estimated duration of 45-60 minutes, with several lasting over two hours. Participants were eager to speak about their conditions, and how they impact their musical lives. The richness of their comments denotes both the ease with which participants discussed their lived-world experiences, as well as their ability to describe the influence of these conditions on highly specific and technical aspects of their musical practices and experiences. Indeed, discussing these questions with highly skilled musicians was central to ensuring the validity of the results obtained.

8.1.1. Key Findings of Aim 1

Aim 1 Question: Does the possession of synaesthesia and/or absolute pitch impact the cognitive, affective, and behavioural outcomes of musical development, and if so, to what extent?

The initial aim of this study was to assess the impact of the possession of synaesthesia and/or AP on the nature and scope of specific musical abilities. The interview data revealed, however, that participants did not typically focus their comments on the practical benefits or disadvantages of either condition. Instead, when discussing the impact of their conditions on their musical abilities, they intuitively focused on the cognitive and affective aspects of their musical development. This meant that much of the analyses of the participants interviews was focused on the lived-world experiences of this unique group of musicians, the importance of their idiosyncratic perceptual experiences, and the personal relationship and engagement they reported with music.

The following subsection provides a framework within which these findings can be examined.

8.1.1.1. A cognitive-affective-behavioural (CAB) model of musical development.

The data obtained from this study was found to be neatly divisible into four results chapters, with the first three of these focusing on the reported cognitive, affective, and behavioural outcomes of the possession of these two conditions. While synaesthesia and AP were indeed reported as affecting specific musical abilities (as described in Chapter 6: 'Behaviour'), participants displayed an observable augmentation in both quantity and interest of responses for questions pertaining to the cognitive and affective results categories. By far the most insightful participant comments were consequently classified in the cognitive and affective domains. The three results chapters were ordered as cognition, affect, and behaviour (CAB) to reflect the underlying importance of each domain in establishing the basis of participants' musical development.

When defining, describing, and delineating the scope of musical development, current practice focuses almost exclusively on behavioural manifestations. Attention is therefore concentrated on how musical abilities can be taught and improved, by creating teaching methodologies aimed at enhancing aural skills and technical aspects of performance. As a result of this approach, much is known about the testable outcomes of these interventions: the 'what' and 'how' of musical abilities. Yet this is only the observable "tip of the iceberg" - as coined by Benjamin - while less is known about the 'why' of these same abilities. Indeed, Benjamin provided a remarkably

perceptive (and metaphoric) overview of the relative importance of labelling notes within the context of AP ability in its entirety:

> BENJAMIN: It's a bit like an iceberg: you see the top of it. That's the superficial thing; that's the clinical definition. That's the thing that people see, and it is an integral part of it and it is a basic part of it, but that is a result of something that's a lot more complex and deep.

For Benjamin, the emphasis is clearly placed on the 'submerged', but much larger and consequential, influences of his AP ability: namely, his personal relationship and deep engagement with keys, and sound in general. Labelling notes is merely the "tip of the iceberg": the seen "party trick" that everyone admires and potentially envies. For him, however, this was missing the crux of what makes AP so fundamental to his musical identity. This sentiment was a recurrent theme in conversations with both synesthetes and AP possessors during this study. Thus, to progress in understanding musical development, it is important to differentiate between visible behavioural outcomes and the underlying cognitive and affective driving forces of these outcomes.

The results of this study indicate that the development of musical abilities begins at a foundational *cognitive* level, with memory encoding and multimodal mental imagery. Enhancements in these domains exert an initial developmental influence on *affective* states, specifically motivation, identity, and emotion. These affective outcomes, powered by the underlying cognitive framework within which they operate, have consequences and implications for *behavioural* outcomes, notably choices, preferences, and performance. Thus, what this study compellingly highlights is the

bottom-up directional impetus of musical development. This cognitive-affective-behavioural (CAB) model therefore provided a framework for the organisation of the results collected (see Figure 8.1).

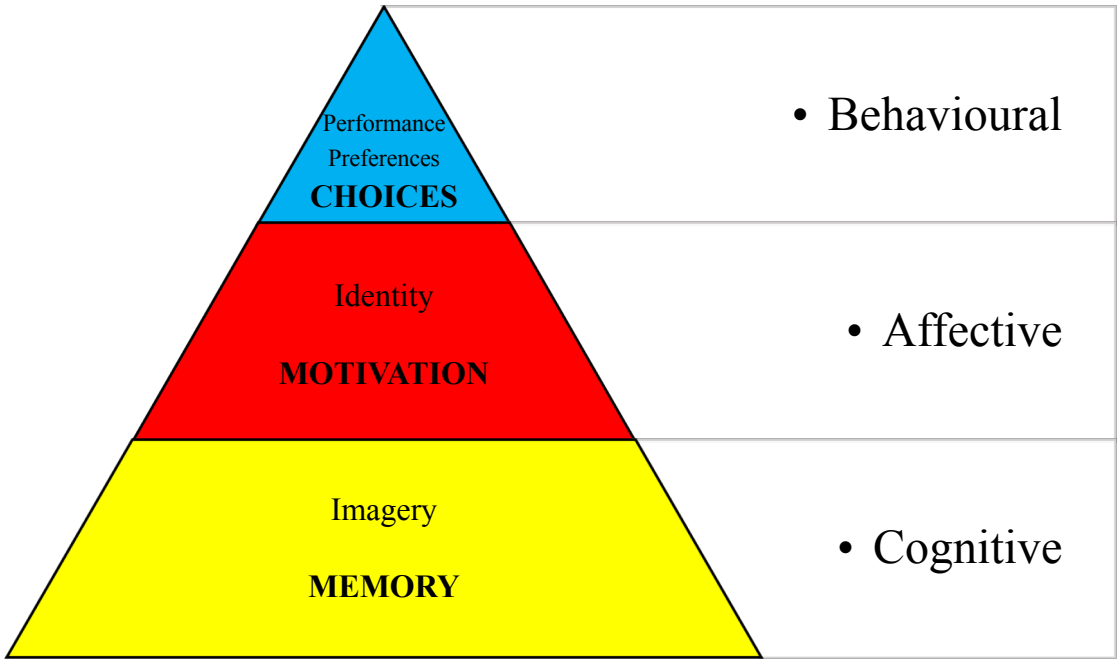

Figure 8.1. A Cognitive-Affective-Behavioural (CAB) Model of Musical Development. Musical development relies on a bottom-up directional impetus, from cognitive, to affective, to behavioural outcomes. Feedback occurs reciprocally between categories within each level. By enhancing cognitive and affective outcomes, and therefore fostering a sense of purpose within musical interactions, synaesthesia and AP drive behavioural outcomes: illustrated here as the 'tip of the iceberg'.

Synesthetes and AP possessors have distinct beliefs about how their conditions affect them on both cognitive and affective levels. The salient and overwhelmingly advantageous cognitive outcomes reported by participants impacted their sense of competence and autonomy, thus increasing their motivational drive to study music at a tertiary level. Their conditions were frequently reported as adding purpose to their musical activities, and lives in general, while being integrated into their identities. For the participants in this study, the possession of synaesthesia and/or AP therefore drives how they experience and interact with music at a deeply personal level.

8.1.1.2. Individualised responses and between-group similarities.

One key aspect of the results obtained in this study is their participant-specific nature. The richness of the data collected is the individuality of these life stories, as the interviews reveal personal vignettes concerning each musician's unique development. The results do not illustrate homogeneous reactions or outcomes among participants. What they do show, however, is a multiplicity of outcomes, enhancements, and changes at the individual level. This is important, as a behaviourist interpretation of this data is therefore untenable, with no single outcome-specific thread established. At both a cognitive and affective level, a complex and individualised profile can be drawn for each participant. Even comparable behavioural manifestations are the product of specific underlying internal mechanisms; behaviours are thus indicators of a multitude of different cognitive-affective sources.

A number of other findings arose from the obtained results: among the most relevant is the similarity of results obtained from both synesthetes and AP possessors. Indeed, although attempts were made to find generalisable differences between groups (synesthetes, AP possessors, and participants with both conditions), there was far greater inter-subject, rather than inter-group, variation. In situations where results obtained from all groups were immediately comparable, no discernible meaningful differences were found.

The individuality of responses and between-group similarities confirmed by this study provide an important panorama of the results obtained. To explore these results in closer detail, the key insights gained from interviews with participants concerning the

cognitive, affective, and behavioural outcomes of the possession of synaesthesia and AP on musical development are discussed in the following subsection. As the results chapters all contain brief summaries of the results obtained, the following section focuses on an analysis of broader topics that arose during discussions with synesthetes and AP possessors, and is divided into two parts. To begin, an evaluation of results that support and extend previous findings is undertaken. This is followed by an examination of unexpected results, which came to light during the data analysis stage.

8.1.1.3. Results that support and extend previous findings.

The first research aim was to evaluate the impact of synaesthesia or AP on the cognitive, affective, and behavioural outcomes of musical development. Results obtained during this study that support and extend previous findings for each of the three initial results chapters are reviewed.

8.1.1.3.1. Synaesthesia, absolute pitch, and cognitive outcomes.

The key findings of a number of recent studies demonstrate a positive link between synaesthesia and memory, with advantages occurring when the task is in relation to a synesthete's specific form of synaesthesia (see Chapter 2.1.6.1.: 'Synaesthesia and memory'). It is important to note, however, that these studies are limited in scope, and do not include music; the results of this study are therefore an important addition to the current research literature on synaesthesia and memory. In the absence of empirical testing regarding music related forms of synaesthesia, it was speculated that the same would hold true for synesthete musicians, especially in situations where they are aware of this memory enhancement, and actively used their synesthetic percepts to aid in their music memorisation. The self-reports detailed in Chapter 4.1.1.1.

('Synaesthesia as a mnemonic aid') indicate this advantage extends to music-related forms of synaesthesia, with all 18 synesthetes in this study (100%) reporting a memory advantage, directly linked to their synesthetic percepts. This advantage is both mnemonic and structural, and can aid participants in overcoming memory lapses, which in turn enhances confidence in performance situations. These results are consistent with the hypothesis that synesthetic percepts lead to richer encoding and retrieval opportunities (Rothen et al., 2012), as well as enhance a synesthetes ability to structure and organise memory: in this case, music.

Overall, the results described in Chapter 4.1. ('Memory') suggest that both synaesthesia and AP create unique learning opportunities inaccessible to musicians who do not possess either condition. It can be speculated that the differences found between participant reports as to the strength or importance of this advantage may be attributable to the fact that certain participants engage with their percepts or associations more readily, and explicitly use them as mnemonic strategies. Indeed, one positive outcome of the interview process was the repeated admission by participants that they intend to explore their unique relationship with music further. Included in this exploration was their stated desire to further develop mnemonic strategies based on their unique percepts and associations.

The data presented in Chapter 4 ('Cognition') corroborates previous studies showing a cognitive advantage for synesthetes over non-synesthetes (Radvansky, Gibson, & McNerney, 2011; Rothen & Meier, 2009; Simner & Bain, 2017; Yaro & Ward, 2007), and supports the theory of an improved perceptual and cognitive organisation suggested by Ramachandran and Azoulai (Ramachandran & Azoulai, 2006).

Importantly, the current data extends this theory to include AP.

8.1.1.3.2. Synaesthesia, absolute pitch, and affective outcomes.

This study is the first of its kind to systematically examine the link between synaesthesia and motivation. These results do, however, reinforce research demonstrating that synesthetes are more likely to undertake tertiary studies with a heavy focus on creativity, or to be employed in the creative industries (Cytowic & Eagleman, 2011), by providing evidence of enhanced enjoyment and connection with music, as well as a reported greater sense of purpose and career direction due to the possession of synaesthesia.

Furthermore, the results extend this outcome by suggesting this gravitation may mirror the specific type(s) of synaesthesia a synesthete possesses. Indeed, prior studies have noted that music or sound induced forms of synaesthesia are less prevalent than other forms (such as grapheme→colour or spatial-sequence synaesthesia), with sound-related forms of synaesthesia only accounting for approximately one in five cases (Day, 2005). In this study, however, music-induced forms of synaesthesia were the most prevalent forms reported (Chapter 7.2.1.1.: 'Synaesthesia inducers'). Importantly also, an overwhelming majority of synesthetes (17 of the 18 synesthetes) possess at least one form of music-related synaesthesia (see Appendix A). The predominance and prevalence of music-induced forms of synaesthesia in this study advances the proposition that synaesthesia confers domain-specific advantages and can be a considerable motivational catalyst.

As no studies to date had specifically investigated whether AP can be understood as a motivational force for an AP possessing musician, the results outlined in Chapter 5.1. ('Motivation') extend the proposition outlined above in relation to sound-induced forms of synaesthesia to include AP, which was analogously reported as enhancing motivational drive to undertake music studies at a tertiary level.

To advance and extend the investigation of the role of synaesthesia and AP on a musician's motivation to continue music studies at a tertiary level, the question was asked: What is the extent to which a participant's choice of area of study or career is determined by the development of a positive musical identity, and what role or roles can the possession of a condition, such as synaesthesia or AP, play in this development?

One reason people feel motivated to identify within a group is to feel their past, present, and future are connected. This is labelled as a *continuity motive* within the motivated identity construction theory (MICT; Vignoles, Schwartz, & Luyckx, 2011). Synesthetes and AP possessors can therefore be presumed to identify with their conditions in large part due to the continuity and presence of these conditions throughout their musical development. Taking a longitudinal approach, we find indications of this continuity across the developmental timespan, epitomised by both the perception of the condition(s) being present for as long as participants can remember (or having an innate or genetic link), and the fear generated by the idea of the potential loss of the condition (for example through ageing, or accidental brain trauma).

The statements collected during this study establish that possessing synaesthesia or AP contributes substantially to an intense and compelling sense of musical identity. Yet this strong identification with the condition(s) can also be restrictive for possessors. Within the construct of possessors' musical identities, a combination of over-dependence and fear of loss was one of the strongest indicators of the importance (and therefore influence) attached by each individual to their condition(s). Specifically, from the perspective of AP possessors, the awareness that their AP might potentially fade away or be lost undermines the above-mentioned *continuity motive* of their musical identities, and therefore places their AP in a position of instability. As AP was habitually described as a fundamental and even central part of participants' musical identities, this instability generates considerable concern and anxiety.

The results outlined in Chapter 5 ('Affect') provide enhanced insights into the way individuals arrive at a sense of musical identity, and how these changes are associated with individual differences in perception. Specifically, assessing the role of the possession of unique neurological conditions on motivation – in this case synaesthesia and AP – provides a framework for understanding the formation of musical identities.

8.1.1.3.3. Synaesthesia, absolute pitch, and behavioural outcomes.

One observed consequence of the possession of synaesthesia or AP on musical development was the importance of experiential feedback in shaping behaviour. The results obtained in this study corroborate the behavioural outcomes of previous research into the impact of AP on specific musical tasks. These include the positive effect of AP on music dictation tasks, and the inhibitive effects of AP on

transposition, playing a transposing instrument, and relative pitch ability (Dooley & Deutsch, 2010, 2011; Mito, 2003). As no previous research has examined the impact of synaesthesia on specific musical tasks, this study extends these findings to include the potentiality for synesthetes to experience similar enhancements and difficulties. What is more, the results obtained expand on these research outcomes, by establishing that synesthete and AP possessing musicians employ their unique perceptual experiences in compositional and interpretative decision-making. Finally, synaesthesia and AP were ascertained as directly influencing musical preferences and repertoire choices.

8.1.1.4. Unexpected results.

An analysis of the interview data uncovered two unanticipated outcomes: the appearance of complex visual imagery (CVI) in reports from both synesthetes and one AP possessor, and the utilisation of a 'sound bank' for AP development and labelling. Furthermore, the potentiality to redefine AP in light of these findings is discussed.

8.1.1.4.1. Discussion of complex visual imagery.

Synesthetic percepts are reported in the research literature as being simple in form (Cytowic, 1989; Hochel & Milán, 2008). Consequently, the interview template of this study did not include questions intending to assess the appearance of complex visual imagery (CVI) with participants. The first encounter with involuntary CVI in the synesthete population of this study occurred during the interview with Ethan, where he unexpectedly depicted the music-induced complex images he experiences. These images are intrinsically linked to his synesthetic colour percepts, and were initially dismissed as an anomaly, potentially linked to his epilepsy and subsequent seizures.

This evaluation came into question when, in an interview the following day, Charlotte spontaneously offered strikingly similar accounts of CVI. It was clear, therefore, that this complex imagery was an integral component of the synesthetic percepts described by these participants, and no more exceptional to them than the colours they perceived. Questions pertaining to CVI were therefore added to the interview template, and three more cases of CVI were uncovered.

Perhaps somewhat surprisingly, there do not appear to be any differentiating characteristics between the five cases of self-reported CVI and the other synesthetes or AP possessors in this study. An examination of the types of synaesthesia and demographic characteristics of these participants uncovered no specific conditions that could be suggested as characteristic of those participants who reported experiencing CVI.

One unforeseen result within participant descriptions of their synesthetic percepts was the almost total lack of reference to any of Klüver's form constants (see Chapter 2.1.3.2.: 'Synesthetic percepts are consistent and generic', and Chapter 4.2.2.2.: 'Complex visual imagery (CVI)'). This was true of the entire group of synesthetes, and not just within the group of five participants who experience CVI. Three minor cases of form-constants were uncovered within the synesthete group as a whole: Charlotte (musical scales inducing bubbles that morph), Thomas (loud noises such as 'bangs' inducing black and white sparks), and Jack (individual notes inducing coloured clouds). Indeed, examples such as Mason, who when asked if he saw shapes, lines, or zigzags replied, "No, definitely not that", are even more unexpected in light of the reports of involuntary *complex* visual imagery.

The reported deficiency of forms or shapes in response to musical stimuli is remarkable. Indeed, Charlotte indicated music always induces images: “Yes, if it's a full phrase or a piece of music, they always do. They're always with images. If I'm listening to disjointed notes, then they're just a colour.” Charlotte differentiated between “music” and “notes”, and this distinction is key to understanding the phenomenon of CVI induced by music. Ordinal systems, such as musical scales, are comparable to linguistic ordinal systems such as alphabetic systems and numbers. As such, these musical systems mirror what we know of synesthetic percepts which include colours and simple form constants. For Charlotte, her scales are an excellent example of this, and are indeed an illustration of what could be included as a description of Klüver’s form constants, as they are circular formations that ‘drift’: “They kind of morph…it's like I'm looking at these changing shapes. They're like bubbles. You see bubbles blowing on the breeze except these ones are filled in and they're coloured. They morph as the scale goes up.” Once her listening experience involves ‘music’, and not just an ordered system of notes, she will automatically experience CVI, which mirrors the complexity and movement of the sound source she is experiencing.

To ascertain whether the cases of CVI reported in this study could potentially be validated as genuine forms of synaesthesia, the descriptions provided by the five participants were compared to the five diagnostic criteria of idiopathic synaesthesia (Chapter 2.1.3.: ‘Diagnosing idiopathic synaesthesia’):

1. Involuntary and Automatic.
2. Consistent and Generic.
3. Spatially extended.

4. Memorable.
5. Affect-laden.

Of these five criteria, it is the first two that are generally regarded as crucial to ascertaining a diagnosis of synaesthesia. The images depicted in the cases of CVI reported in Chapter 4.2.2.2. ('Complex visual imagery (CVI)') were validated as being involuntary and consistent, thus meeting the first two diagnostic criteria. Four participants indicated visualising the images in their 'mind's eye', with only Ethan reporting experiencing images projected in his peripersonal space. This is in keeping with his coloured percepts which are also projected. In this sense, CVI appears to mirror the participants' other forms of music-induced synaesthesia. In the unique case of Lucas, who does not have synaesthesia, CVI was similarly reported as being experienced in his mind's eye.

All five participants acknowledged that their CVI is memorable. Furthermore, the affect-laden aspect of the CVI described in each case can be discerned in two ways. First, all five participants noted a feeling of certitude and conviction as to the validity of their images. The reality and validity of these images was clearly evidenced by Ethan's account of "reaching" for these images in his peripheral vision as a child (Chapter 4.2.2.2.1.1.: 'Case study 1: Ethan'). Second, these images can be associated with both agreeable and disagreeable emotional responses. Charlotte's admission that she is drawn to music that induces "nice" colours or images, and conversely dislikes music that induces disagreeable colours or images, is an exemplifying case in point (Chapter 4.2.2.2.1.2.: 'Case study 2: Charlotte').

The five cases of CVI considered in this study have consequently been found to validate all five diagnostic criteria for synaesthesia, except for the second requirement of the second criterion (that percepts are generic or simple in nature). These cases report involuntary, stable mappings, which are furthermore noted as being spatially extended, memorable, and affect-laden. These percepts are not, however, 'generic'. Thus, it can be argued that the cases of CVI reported above are genuine examples of synesthetic percepts if the requirement that percepts be 'generic' is taken to be more descriptive than diagnostic, or if the field of accepted synesthetic percepts is extended to incorporate some or all cases of involuntary, automatic, and consistent music-induced CVI.

On reflection, it is not surprising that research to date - which tends towards the investigation of ordinal forms of synaesthesia - has not yet uncovered cases of involuntary CVI as a synesthetic phenomenon. As the case of Charlotte strikingly depicts, the ordinal systems of music and other symbolic systems, such as alphabets and numbers, do indeed appear to induce colours and simple forms. As ordinal forms of synaesthesia, such as grapheme→colour synaesthesia, are by far the most widely studied, contemporary research has consequently (if indirectly) hindered research opportunities of other forms, specifically in the domain of music-induced forms of synaesthesia. Indeed, in a recent article, Meier and Rothen (2015) explicitly called for future studies to address "the development of other forms, for example, sound-colour synaesthesia" (p. 2).

Music is not purely the sum of its notes. Music is a temporal art, with movement, form, structure, and emotional induction. Consequently, it is possible that music-

induced multimodal mental imagery (MMI) in general – and CVI in particular – exists due to music's temporal and complex structure, which CVI mirrors. Expanding synaesthesia research more broadly to include music-related forms of synaesthesia was therefore an important direction for this study to take.

8.1.1.4.2. Discussion of the development of a 'sound bank', and redefining absolute pitch.

Scrutiny of a theory of the storage of pitch memory within an internal 'sound bank' for certain AP possessors was undertaken as a final part of the analyses. Absolute pitch ability does not involve superior pitch differentiation in comparison to non-AP possessing musicians but is reliant on long-term memory and linguistic coding (Levitin, 1996). The role of long-term memory in the development of AP was considered in this study in relation to the storage of excerpts of idiosyncratically meaningful pieces or songs deposited before the onset of formal musical training.

Three participants in this study - Oliver, Noah, and Lucas - described having the awareness of a classifiable pitch system, as a fundamental element of the music they were hearing, for as far as they could remember, and certainly well before the onset of musical training. They did *not*, however, describe pitch-labelling occurring at this time. Once formal musical training began, they were then able to use a 'sound bank' or similar pitch classification system to assist them in learning the labels associated with those pitches. This strategy was typically accompanied by a second strategy that employed the visual image of an instrument (piano or guitar in these cases) to facilitate pitch labelling. For all three participants, these 'sound bank' deposits

enabled pitch sensitivity and differentiation to develop into pitch labelling, and thus the current definition of AP.

One potential problem of the AP definitional criteria that requires addressing is the requirement for possessors to correctly 'label' pitches. This presupposes a relatively high level of formal musical training in a (predominantly) western intervallic system. The cases of CVI outlined above, however, indicate that an underlying ability to differentiate between different musical pitches can exist independently of a pitch-labelling ability. It could therefore be conjectured that a section of the population may possess a concealed form of AP, which would remain unrecognized due to their lack of formal musical training. Pitch-labelling could thus potentially be 'acquired' at a later stage through exposure to specific pitch→label associations. The case of Lucas exemplifies this premise: Lucas indicated his "pitch sensitivity" has existed "for as long as I can remember" (see Chapter 4.1.2.5.2.: 'Lucas'). The "arbitrary concept of assigning letters to individual pitches", however, is an ability he learnt during his late teens, shortly before entering the Conservatorium. Descriptions such as those provided by Lucas consequently underscore an obstacle in how AP is currently defined, which automatically excludes anyone without formal musical training.

Our enhanced understanding of the complexity and multimodality of the AP labelling process obtained in this study reinforces the argument that AP ability may be less contingent on early exposure to specialised music education than is currently conjectured (Ockelford, 2016). Rather, the statements obtained by participants in this study suggest that pitch-labelling is the final stage of a far more complex perceptual process. The potentiality that we were all born with AP, but generally lose the ability

through typical neuronal pruning at a young age, is one conceivable rationalisation of the results obtained within this study (Saffran & Griepentrog, 2001). Absolute pitch possessors would therefore be presumed to be able to *retain* pitch-differentiation abilities beyond the habitual time frame, potentially due to genetic factors (as was often believed to be the case by AP possessors - and synesthetes - in this study; see for example Chapter 5.1.2.2.: 'Purpose', and Appendix A).

These results suggest that an enhanced definition of AP is necessary, which focuses more on underlying perceptual subprocesses and less on pitch-label associations. The results analysed in Chapter 7 ('Idiopathic Synaesthesia and Absolute Pitch: Interactions and Comparisons') provide further evidence for a reconceptualising of AP ability. This proposition is explored in the following discussion subsection regarding Aim 2 of this study.

8.1.2. Key Findings of Aim 2

Aim 2 Question: For participants who possess both conditions, is there evidence to suggest they interact, and if so, in what ways?

The second research aim of this study was to examine the potential interaction between synaesthesia and AP. When combined, Chapters 4-7 offer a detailed explanation of how both synaesthesia and AP affect, and are affected by, the perceptual experience of music and music making. The analyses uncovered substantial similarities between synaesthesia and AP. This discussion section therefore examines whether the two conditions might be phenomenological variations of the same condition.

As noted in the Literature Review (Chapter 2.3.: 'Synaesthesia and absolute pitch research'), the co-occurrence of synaesthesia and AP in professional musicians has been observed (Bernard, 1986), while neuroimaging and genetic studies have reviewed parallels between both conditions (Gregersen et al., 2013; Loui et al., 2012; Mottron et al., 2013; J. Ward et al., 2006). In addition, both Gregersen and colleagues (2013) and Mottron and colleagues (2013) noted a higher prevalence rate of synaesthesia and AP in subjects with autism spectrum disorders, with the latter proposing that synaesthesia and AP involve similar neurocognitive components, share the same structural and developmental progression, and represent related ways by which the perceptual brain deals with objective structures under different conditions.

Although their co-occurrence has been frequently noted, synaesthesia and AP are often discussed separately in the literature, without being directly compared. Importantly, several key questions arise when reflecting on the relationship that exists between them. Is the phenomenology of synaesthesia and AP comparable, and if so, to what extent? Can knowledge about one condition be applied to our understanding of the other, and if so, can that transferal inform or even alter our perception of one or both conditions? Is there the opportunity to evoke the possibility of an integrated, singular phenomenon?

Based on a comparison of the descriptions presented in the previous results chapter (Chapter 7: 'Synaesthesia and Absolute Pitch: Interactions and Comparisons'), the initial question outlined above, concerning the extent to which features of synaesthesia and AP can be compared, has been answered. This analysis suggests that

the phenomenology of synaesthesia and AP contain strikingly similar elements and are in many cases identical. The ensuing questions, regarding the alteration of our perception of one or both conditions, and the possibility of evoking an integrated, singular phenomenon, therefore require further consideration. The following discussion subsection addresses these questions, by comparing the perceptual subprocess of AP against the five diagnostic criteria of synaesthesia.

8.1.2.1. Absolute pitch and the five diagnostic criteria of synaesthesia.

The results outlined in Chapter 7 ('Synaesthesia and Absolute Pitch: Interactions and Comparisons') logically lead to the proposition that both synaesthesia and AP could potentially be phenomenological variants of the same, integrated, condition. This possibility is not without empirical corroboration, as numerous recent neuroimaging and genetic studies have confirmed parallels between both conditions (Gregersen et al., 2013; Loui et al., 2012; Mottron et al., 2013; J. Ward et al., 2006). This section consequently addresses the question of the potential validation of AP as a type of synaesthesia, by applying the synesthetic diagnostic criteria to AP.

The five diagnostic criteria of synaesthesia indicate it is involuntary, consistent, spatially extended, memorable, and affect-laden (Chapter 2.1.3.: 'Diagnosing idiopathic synaesthesia'). As previously suggested, the first two criteria are regarded as essential features of the synesthetic phenomenon, whereas the final three criteria represent characteristics observed in the majority of cases. In this subsection, AP will be compared against the diagnostic criteria of synaesthesia, with a particular focus on the involuntary and consistent nature of the AP perceptual process.

8.1.2.1.1. Absolute pitch: involuntary and automatic.

Synesthetic percepts cannot be suppressed nor evoked, and synesthetes are unable to control their appearance in response to a given inducer. These synesthetic percepts appear automatically at the commencement of the stimulus and stop once it has been eliminated. From an AP-labelling perspective, examples of this automaticity are plentiful. James, for example, noted: “Automatic and involuntary. I've tried turning it off. I've tried doing melodic dictations in class without having to rely on pitch, instead relying on intervals. I've been getting better at it but it's like an automatic reflex. I just know what that pitch is. It's like a muscle movement. It just happens automatically.” This sentiment is also expressed in relation to the visual keyboard concurrent depicted by possessors such as Joshua, who indicated this image is not only automatic and involuntary, but also “instinctive”. Benjamin expanded on this, by noting that his dual visual-tactile percepts are automatically induced by the instantaneous pitch recognition of any music, even with unfamiliar music. The auditory stimulus (individual notes or tonalities) is therefore automatically triggering the visual and tactile domains (keyboard image and corresponding sensation on the tips of his fingers).

Note that the *intensity* of synesthetic percepts is reported as being variable depending on the synesthete’s level of attention, and this is a theme that has played out in the responses of AP possessors as well. Joshua stated: “I'm not sure I can think of turning it off, but I can think of turning it on. I can listen to something without consciously thinking about what the pitches are. Then I might wonder to myself, "Oh I wonder what note this is."” Once his attention is focused on the pitch content of the music, his AP processing – including visual concurrent – is involuntarily and automatically

present. The AP process, while reliant on conscious attentional awareness as is indeed the case with synaesthesia, can therefore be defined as being automatic and involuntary.

8.1.2.1.2. Absolute pitch: consistent and generic.

Synesthetic percepts are highly idiosyncratic, and once initially established are consistent and stable over the synesthete's lifespan. As such, an inducer will always trigger the same concurrent. By its very nature, AP can be viewed as a stable mapping between a heard note (inducer) and a pitch label (concurrent). This concept was extended in this study to include the visual image of a keyboard, sound bank of familiar songs, and tactile sensations. These concurrents (visual, auditory, and tactile) rely on vivid and stable mappings, thus drawing strong parallels with synesthetic percepts. When defining other characteristics associated with individual notes or tonalities, AP possessors described individual notes as having specific and idiosyncratic characteristics, including personality, colour, texture, and warmth. The consistency of these percepts was reported by AP possessors such as Liam, who indicated that the tactile sensations he feels in response to music are stable, regardless of instrument or sound source. Still other possessors, such as Benjamin, acknowledged that their secondary associated percepts are present when listening to music of any repertoire, thus indicating that the associated percepts are a stable pitch-identification reference.

The second requirement of this criterion concerns the generic and limited aspect of synesthetic percepts, which are noted for lacking elaborate or pictorial representations. Yet as discussed in Section 8.1.1.4.1. ('Discussion of complex visual

imagery'), the appearance of cases of CVI suggests this auxiliary sub-criterion may be unreliable and restrictive. Discussion of the concurrents present during the AP process uncovered further cases of CVI, including keyboard and score visualisation. Indeed, even the auditory imagery noted in relation to the construction of a 'sound bank' can be described as 'complex' auditory imagery (Section 8.1.1.4.2.: 'Discussion of the development of a 'sound bank', and redefining absolute pitch'). These composite percepts are nevertheless consistently paired with the inducing note or tonality and are furthermore fundamental to the development of the pitch-labelling process.

Absolute pitch percepts, including note-labelling, auditory, visual, tactile, or personality characteristic percepts, are therefore consistent and – once established – stable. They are not, however, *generic*, as many percepts were noted as being perceptually complex. Yet as previously discussed in this chapter, non-generic synesthetic percepts, such as CVI, have been identified. It therefore appears that these complex percepts inevitably result from the intricacy and temporality inherent to music. This would justify the complexity of percepts depicted by both synesthete and AP possessing musicians within this study.

8.1.2.1.3. Absolute pitch: spatially extended (associator versus projector).

Two qualitatively different ways of experiencing synesthetic percepts have been documented, with synesthetes categorised into two main groups based on this dichotomy:

> Group 1: who report experiencing percepts externally (in their peripersonal space, or directly onto the inducer), are named *projector* synesthetes.

Group 2: who report experiencing their synesthetic percepts interiorly, are labelled *associator* synesthetes.

Both groups indicate experiencing percepts of the same level of automaticity and stability. While traditional concepts of AP-labelling are difficult to depict spatially, the reports of keyboard visualisations analysed in this study have a distinctly spatial quality, and in many ways mirror spatial-sequence synaesthesia, in the automaticity and stability of the percepts, and in the assertion that these images are situated in the participant's mind's eye, and are thus spatially extended (see Chapter 2.1.5.2.: 'Prevalence of different forms of synaesthesia', for a description of spatial-sequence synaesthesia). While not all AP concurrents defined in this study could be depicted spatially, those percepts with a distinct spatial quality were systematically asserted as occurring internally, in the mind's eye or mind's ear.

8.1.2.1.4. Absolute pitch: memorable.

Synesthetic percepts are clearly remembered and can be used as a mnemonic device. The mnemonic benefits of AP were discussed in Chapter 4.1. ('Memory'). These benefits include the use of AP as a mnemonic and structural aid, and the positive impact this has on memorisation speed. It is clear that AP labels are intrinsically memorable, and this is also demonstrable when looking at the extra-sensory and categorical concurrents reported by AP possessors in this study. The mnemonic advantage of developing an internal 'sound bank' of discrete pitches, for example, was discussed in Chapter 4.1.2.5. ('Sound bank and absolute pitch development'). The storage of specific memories of individual notes not only acted as a mnemonic aid, but also facilitated the development of participants' pitch-labelling abilities.

Within the descriptions provided by AP possessors in this study, the mnemonic interplay between various senses or sense modalities is striking. To reiterate the remarks of Benjamin, “If I'm memorising at the piano, it will always be to do with: it's in this key; it feels like this; this is how it feels in my body. It couldn’t be any other key, it's just that: that's its personality.” This multisensory memorisation strategy was also noted by Liam, who suggested that the integration of auditory, visual, and tactile percepts was the foundation of his self-reported exceptional music memory.

8.1.2.1.5. Absolute pitch: affect-laden.

Synesthetic percepts can be highly affect-laden or emotionally charged, in either an agreeable or disagreeable way. The agreeable nature of the emotional aspect of AP concurrents was exemplified in conversation with Max. While it was ascertained that Max does not have synaesthesia, he did however indicate a strong sense of music-induced emotions, specifically linked to individual tonalities: by consequence intimately linked to his AP. These emotions fall under the archetypal umbrellas of ‘major = happy’ and ‘minor = sad’, but then differentiate into more nuanced emotions, carried by specific keys:

> MAX: Emotion: a certain key or tonality will have an emotion attached to it and the progression of chords has - for me - a definite [pauses] emotion attached…For me, I hear that constantly. So, when I say emotion with sound, that for me is intertwined with interpreting music…something that's in E flat minor will always be tense and always a little bit angry, restless, anxious: will always have a slightly uncomfortable element to it…So comparing to, let's

> say, F minor which is far more angry and full of rage I suppose. Same with D minor. It's a more direct anger I suppose…B minor is generally either restless or kind of withheld anger or deep inside so not something that comes out immediately.

Max perceives these emotional associations constantly, and they are "intertwined with interpreting music". Max suggested the strong associations he feels with particular keys are intrinsic to those keys, and that if played well, he is automatically impacted by those associations from the very first bar of the piece.

If, conversely, synesthetic percepts are incongruently matched to an exterior source, this can lead to a negative emotional response. From an AP perspective, this potentiality was discussed in Chapter 6.3.3.2.2. ('Performing at baroque or classical pitch'), where participants' described the detrimental aspect of their AP in relation to the overlap of their internal pitch template and a mismatched exterior sound source. This type of incongruent matching is both frustrating and restrictive.

The emotions evoked by a piece of music were frequently reported by AP possessors as being heavily linked to the key of the piece. This extra dimension to music-evoked emotion appears to be absent from non-AP processing. The knowledge of the tonality of a given piece allows AP possessors to experience the idiosyncratic emotional characteristic of individual tonalities.

8.1.2.1.6. Summary of absolute pitch and the five diagnostic criteria of synaesthesia.

Comparable to synesthetic experiences, the variances in the process involved in AP labelling, and their descriptions, were demonstrated to be highly individualistic. Indeed, not all AP-associated percepts reported can be interpreted as concurrent synesthetic percepts. The results of this study nevertheless reveal that even though not all AP cases studied positively meet all 5 criterions – as is indeed the case with synaesthesia – all AP cases studied meet the diagnostically crucial first two criterions as long as, in some cases, the less important auxiliary requirement of the second criteria ('generic'), is revised and qualified as suggested above (Section 8.1.1.4.1.: 'Discussion of complex visual imagery'). All AP possessors who indicated experiencing a secondary perceptual aspect to their pitch-labelling process did, therefore, include at least one concurrent that meets the diagnostic criteria of being automatic, involuntary, and consistent. The five diagnostic criteria of idiopathic synaesthesia (Cytowic, 2002) are therefore applicable to the majority of AP cases reported in this study (89.3% of AP possessors, n=25; see Chapter 7.2.2.2.: 'Absolute pitch concurrents').

When compared against these diagnostic criteria, examples of AP concurrents that were involuntary, consistent, spatially extended, memorable, and affect-laden were provided. To return to the questions outlined in the introduction to this discussion section, and after previously ascertaining the similarity of the phenomenological features of both synaesthesia and AP (Chapter 7.2.: 'Phenomenology of inducers and concurrents'), the question regarding the potential alteration of our perception of one or both conditions can now be answered. Following on from the successful application of the diagnostic criteria of synaesthesia to AP percepts, it can be

acknowledged that our understanding of AP, when viewed through the lens of these diagnostic criteria, is substantially altered.

Applying the diagnostic criteria of synaesthesia to the AP process exposes the necessity for an updated definition of AP to be formulated. The data reported in this study endorse the possibility of an integrated, singular phenomenon. Not only do the data suggest that AP could be classified as a type of synaesthesia, they also suggest that it might be possible to categorically differentiate AP into *several* idiosyncratic types of synaesthesia. To consider AP as one explicit condition is therefore inaccurate. The inducer→concurrent pairing in AP processing was demonstrated to take on four forms: auditory→auditory, auditory→visual, auditory→tactile, and auditory→personal characteristic (see Chapter 4.1.2.5.: 'Sound bank and absolute pitch development', and Chapter 7.2.2.2.: 'Absolute pitch concurrents'). These four forms are discrete pitch-labelling processes and should be distinguished from each other. Thus, AP can be categorised according to four types: ordinal scalic audiation, ordinal scalic visualisation, ordinal scalic tactile perception, and ordinal scalic personification. As with synaesthesia, however, it is possible (and probable) to have more than one type of synaesthesia operating concurrently. Results obtained in this study are consistent with this conclusion.

8.2. Implications for Research

This study has broadened our understandings of the effects of synaesthesia and AP on participants' musicianship in general, and of the complex relationship that exists between these two conditions and musical potential and ability. In this way, the results expand conceptions of musical abilities in ways that encompass atypical forms

of processing, such as the multisensory processing found to occur in both synaesthesia and AP. Synaesthesia and AP research is a relatively new and rapidly growing field of interest for both musicologists and psychologists among others, and the richness of the results obtained during this study substantially improve our insights into how these two conditions interact in musical development.

8.2.1. Implications for Individual Musicians

This study has uncovered new insights into the experiences of individual musicians with synaesthesia and AP. By discussing the effects of these conditions with musicians who possess a professional level of musical language, these effects were discerned and explained. Individual participants themselves noted that they benefited from partaking in this research, by having the possibility to talk about and describe their unique perceptions. Samuel, for example, specifically indicated he has never shared the personal nature of his associations and internal lived-experiences with anyone before. Echoing this sentiment, Alexander described the fact that he has never earnestly talked with anyone about his relationship with AP as the reason for his interest in joining this study. Disclosing this information was both a relief, and an enlightening experience for him:

> ALEXANDER: I was very interested when I saw an email last year from Oliver about this study - very interested - because I never really talk about this to anyone. I know people who've commended me for having it and have said, "That's a great talent," but they haven't really asked me questions like you did today, so I felt like I should do the study because today, I think I answered questions that I'd never encountered before.

Alexander delivered a spontaneous message of thanks for having the opportunity to discuss these subjects with someone, as for him this was the first time he has spoken to anyone about many of the topics covered during his interview. He ended the interview by declaring:

> ALEXANDER: I think you've covered a lot today. You've asked lots of great questions that I'd never, ever, ever thought of. It was flawless. It got me thinking, it got me thinking a lot. Some of them were hard to answer because I really had to dig down years and try to think, "What happened? What happened?" So, you really have woken me up a bit with perfect pitch and I think it's great. I've enjoyed it and I'll always think about it more and more.

Alexander remarked that many of the questions unpicked aspects of his ability he himself had never contemplated, which had forced him to reflect more deeply and introspectively on his AP, its mechanisms, and its outcomes. He enjoyed this exchange, which has “woken” him up to a greater level of understanding of his condition: one he is now keen on exploring further.

8.2.2. Implications for Practice

The results of this study have implications on how musicianship is taught to students who possess synaesthesia and AP. Understanding the unique strengths and struggles of individuals with these conditions enables practical adaptions to be made to the design of educational approaches. Defining musical development and learning in terms of neurological and psychological processes enables music curriculums to be

adapted to the perceptual experiences and needs of students, rather than futilely trying to adapt the students to any particular curriculum (for a discussion of neuro-pedagogical practices in music, see Hodges & Gruhn, 2018).

Lily provided one example of the maladaptation of specific teaching styles to her learning. As a synesthete Lily described her frustration when teachers use colours to explain concepts: “It's really frustrating because I'm trying to understand what they're saying and then they completely undermine my capacity to understand.” This was exemplified by an incident that happened in Lily’s first year of her music studies:

> LILY: We did one of the classes called ‘Harmonic Devices’ and you do a lot of interval aural training. In talking about the chords, the notes in the chords and chord extensions, my teacher talked about sound colours. He used these terms so often when he would talk about chords - added colours to the chords. It started to really throw me. One day I was obviously just frowning and going, "What?!" He was talking about opposite colours to use to play outside the chord tones and I was like, "Whaaaaat?!" And he said, "What's wrong?" And I said, "That sounds purple to me! That sounds red and you've just said that they're green and red!" … And so, then he said, "Ah! You've got synaesthesia!" And I was like, "Oh okay."

While Lily had previously heard of synaesthesia as a condition, she was unaware that her unique perceptual experiences could be classified as such. This incident was therefore her first realisation that she potentially had synaesthesia. This newfound

realisation subsequently enabled Lily to discuss her learning difficulties with her teacher, who was able to adapt his teaching to account for her needs.

Participants in this study also provided examples of specific instances in non-music related subject areas where difficulties were faced when synesthetic or AP expectations were not met. One thought-provoking example worth highlighting concerning difficulties experienced in a classroom setting was provided by Benjamin:

> BENJAMIN: I was in Year 9. I was in English class and we were watching a film. In the film, they played an excerpt from the second movement of Beethoven's fifth piano concerto, which I was learning at the time. So, I was particularly sensitive and attuned to it. They'd transposed it up a semitone into C major. [Pauses] I had to leave the room. I had a panic attack, and I don't want to sound melodramatic or anything, but it was so painful - it was physically painful. I had a headache; I just couldn't think; the lights in the room suddenly got too bright and it was painful on my eyes. It was like fingernails down the blackboard: it was the worst kind of [pauses] dissonance - in that metaphoric sense - that you can possibly imagine. It was horrible.

The level of pain Benjamin reported experiencing was so intense that he had to physically remove himself from the room. What is intriguing in this recollection is his insistence on the physical nature of the pain he was experiencing, provoked by the juxtaposition of his aural memory of the correct pitch of the piece, with the actual external rendition of the same music. Indeed, he characterised this as “the worst kind of dissonance”. This is not the first of such episodes, but it is the most memorable for

Benjamin, potentially because of the situation that he was in (a school classroom), and the fact that his teacher was confused by what Benjamin was experiencing. While this example is highly idiosyncratic, it does highlight the need for teachers across disciplines to be educated on the unique learning enhancements and difficulties experienced by possessors of conditions such as synaesthesia and AP.

Translating the highly idiosyncratic learning and developmental trajectories of these participants into complex teaching environments is admittedly challenging. Yet increasing competence and performance in specific musical domains requires cognitive and affective based teaching and learning. When looking at the observable, testable manifestations of discrete performance elements, the focus, as previously noted, is currently on the enhancement of ability from within the *behaviour* box. Yet it is only by stepping down into the realms of *cognition* and *affect* that we uncover answers to the 'why' of musical development.

8.3. Future Research

As an exploratory study, the results presented within this dissertation fulfil an important initial role of uncovering and recounting the lived-world experiences of these unique groups of musicians. The sheer volume of data collected during this study attests to the impact these conditions have on the musical lives of the participants. There is therefore a justifiable need for future research to delve deeper, as this study was only able to peel away the outer layers of what is evidently a highly complex and multifaceted phenomenon. Furthermore, as this study is based on the self-reports of participants, future research is needed to validate claims of cognitive

enhancement, specifically in relation to enhanced memory and imagery (both auditory and multimodal) by possessors of both conditions.

One of the limitations of this study was its inability to explore several fascinating, yet peripheral, themes that arose during the interview process. In this concluding discussion section, four future research topics are therefore proposed.

8.3.1. Secondary Template of Absolute Pitch

One interesting by-product of the transposition impediment occasioned by AP possession was the reported development of a 'secondary-template' for AP. After several years of playing a transposing instrument, or playing or singing at baroque pitch, numerous participants with AP in this study stated they had developed a second AP template. As Oliver indicated: "I guess, in my mid-thirties, what I proved to myself was that if pitch is memory, then you can have more than one memory in the same way as you can have more than one language. It seems that you can have another track." Once established, AP possessors reported that they are able to switch between both templates at will, although a period of 'habituation' was frequently noted as a necessary condition. Participants were unsure, however, whether this second internal template would be retained if they were to cease using it, as is commonly noted with the discontinued use of a second language. For the purposes of this study, this subject was not examined in this dissertation; The development, and subsequent stability and automaticity, of this second internal template therefore warrants future exploration.

8.3.2. Synaesthesia, Absolute Pitch, and Autism

While it is beyond the scope of this study, the relationship between synaesthesia, AP, and autism spectrum disorder (ASD) was suggested and addressed by the two participants in this study who possess all three conditions: James and Benjamin. James noted: "I have a very strong feeling that my perfect pitch is linked to my autism because of the repetitive nature in which I develop memory"; Benjamin, who acknowledged a direct link between all three conditions, echoed this sentiment. Furthermore, the role of exceptional or long-term memory on the development of synaesthesia and AP was also discussed. Specific cases of self-reported eidetic or photographic memory were noted, including the potential link between exceptional memory and autism in participants who possess both. In the Literature Review (Chapter 2.2.4.1.3.: 'The neurological underpinnings of absolute pitch', Chapter 2.3.4.: 'Study 4', and Chapter 2.3.5.: 'Study 5'), the neurobiological and genetic link between synaesthesia, AP, and ASD was established. Future research is therefore required to elucidate this association further, within the context of musical development.

8.3.3. The Impact of Synaesthesia and Absolute Pitch on Musical Development During Childhood

In interviews with participants in this study, accounts were provided from both synesthetes and AP possessors who recalled their earliest memories of their condition(s) as being when they were young children, or indeed as far back as they can remember. This study has shed light on the impact of these two conditions on musical development and perception, however no studies to date have specifically looked at the effects of music-related forms of synaesthesia or AP on the musical or

auditory development of children. Indeed, numerous reports of a 'peak' in precision or strength of their synesthetic percepts or AP ability were provided by participants in this study. What is more, the prevalence rates of these two conditions in children and adolescents is unknown. Future research is therefore recommended to track the development of these conditions from childhood, through to adolescence, and then into adulthood.

8.3.4. The Impact of the Age-related Loss of Synaesthesia and Absolute Pitch on Professional and Personal Musical Engagement

The fear of the loss or degeneration of their condition (either synaesthesia or AP) is a theme that has been explored in this study (Chapter 5.2.3.: 'Fear of the loss of synaesthesia or absolute pitch'). Yet to date, potential changes in the strength or possession of synaesthesia or AP in relation to the ageing process of professional musicians have not been studied. In consequence, both the physical and psychological effects of the age-related loss or change in musical abilities, which are directly affected by the possession of synaesthesia or AP, require addressing.

One synesthete and AP possessor in this study - Mason - acknowledged being a distant relative of the Russian pianist Sviatoslav Richter (Appendix A). In his memoire, Richter reported that the age-related loss of his AP was the catalyst for his retirement from performing, as the juxtaposition of his internal AP template with the external sound of his playing was impossible for him to overcome: "In the past, I always played from memory, but I stopped doing so in the late seventies…I used to have perfect pitch and could reproduce everything by ear, but I noticed that my hearing was getting worse. Today I mix up keys and hear things a tone or sometimes

two whole tones higher than they actually are, except the bass notes, which I hear as being lower than they are…It's sheer torture, and of course it also affects the coordination of your fingers" (Richter, in Monsaingeon, 2005, p. 140). This statement from Richter is reminiscent of Oliver's concession that the deterioration of his AP (due to injury) negatively impacted his auditory imagery, confidence, and performance (Chapter 4.2.1.2.1.: 'Oliver: positive effect of auditory imagery highlighted through a rare case of its loss'). Indeed, the age-related loss of their condition(s) was frequently acknowledged to be a substantial concern of participants in this study (Chapter 5.2.3.: 'Fear of the loss of synaesthesia or absolute pitch'). Despite the existence of documented reports such as those of Richter, and the fear acknowledged by participants in this study, no research to date has examined the psychological and practical impact of the loss or degeneration of either of these conditions on the personal or professional musical lives of possessors. This is therefore one area of research that is in critical need of focused attention.

In conclusion, Sections 8.3.3. and 8.3.4. above are two interrelated future research directions that lie at the heart of this study. As such, an intergenerational research project that addresses both the impact of synaesthesia and AP on musical development during childhood and adolescence, and the impact of the age-related loss or deterioration of these conditions on musical engagement, is encouraged.

Chapter 9

Conclusion

"The only truths that you can be sure of are subjective truths."

Semir Zeki (2016)

The starting point of this investigation into the impact of synaesthesia and absolute pitch (AP) on musical development was the realisation, resulting from my initial review of the literature, that no studies to date had specifically examined the influence of the possession of synaesthesia or AP on the cognitive, affective, and behavioural outcomes of musical development. Furthermore, while the co-occurrence of synaesthesia and AP was frequently reported in the literature, no studies were found which examined the potential interaction of these conditions in musical contexts. This study is therefore the first to examine the effects of these two conditions on musical development, and the mechanisms of their interaction. Moreover, while an etiological evaluation of synaesthesia and AP was beyond the scope of this study, a phenomenological comparison of both conditions was undertaken. This comparison elucidated the potential limitations of the current methodological approach of differentially categorising these conditions. Indeed, while synaesthesia is systematically labelled as a genuine neurological condition, AP is commonly defined as an acquired ability or skill. A major finding of this study, however, is that synaesthesia and AP are phenomenologically comparable.

Two research aims were formulated to optimally examine the unique musical experiences of synesthetes and AP possessors. The first research aim was to identify the degree to which synaesthesia or AP possession may facilitate or impair the cognitive, affective, and behavioural outcomes of musical development. In the Discussion chapter (Chapter 8) the influence of synaesthesia and AP on musical development was assessed, based on the data outlined in the first three results chapters (Chapters 4-6: 'Cognition', 'Affect', and 'Behaviour'). An analysis of the interview data obtained from the participating musicians established that synaesthesia and AP considerably impact musical development. Two cognitive domains – memory and imagery – were frequently described as being substantially enhanced by the possession of synaesthesia or AP. Furthermore, the intersection between music memorisation and various forms of multimodal imagery was reported.

One of the most noteworthy influences of synaesthesia and AP was the acknowledgement by participants that their condition(s) promotes a deep engagement and strong relationship with music. Moreover, two interrelated affective domains – motivation and identity – were reported as being substantially enriched by the possession and unique experiential aspects of these two conditions. The cognitive and affective inner processes of synesthetes and AP possessors were also reported as influencing musical behaviours, including musical choices and preferences, decisions relating to repertoire and concert programming, music listening and stylistic preferences, compositional choices, and instrument choices. Performance aspects of musical engagement, such as interpretation, technique, and transposition, were

similarly acknowledged as being impacted by the possession of synaesthesia or AP, with both engagement and avoidance behaviours described.

Both enhancements and limitations to cognitive, affective, and behavioural outcomes were recognized as being influenced by the possession of synaesthesia or AP. Ultimately, however, all participants indicated they would retain their condition(s) if given the choice, based on a belief that the advantages far outweighed any negative consequences.

The second research aim of this study sought to investigate the potential interaction between synaesthesia and AP for participants who possess both conditions. The dominance, interaction, and separability of synaesthesia and AP were examined. While AP was habitually acknowledged to be the dominant condition, both conditions were generally reported as supporting each other in music-related tasks. Overall, participants with both conditions found it difficult to separate the two, due to their coexistence in musical contexts. Furthermore, the discussion of the results outlined in Chapter 7 ('Synaesthesia and Absolute Pitch: Interactions and Comparisons') revealed that the data collected from participants with both conditions were strikingly similar. This study began as a comparative study, however a phenomenological analysis of the inducers and concurrents of both conditions led to the postulation that synaesthesia and AP might be phenomenological variants of the same condition. Indeed, an analysis of the reports of AP possessors demonstrated that the overwhelming majority of AP cases met the diagnostic criteria for synaesthesia. While further research is needed to test and confirm this finding, synaesthesia and AP may very well be two sides of the same coin.

The findings of this study challenge the notion that research can examine auditory processes of music perception independently of the other senses, particularly vision. Instead, it demonstrates that synaesthesia and AP are two multisensory representational systems that enhance our understanding of the rules that underlie the interaction of our senses at an experiential level. While this interactive process has been shown to be conscious for synesthetes and AP possessors, it is possible that it might also operate unconsciously in non-possessors. If this possibility could be substantiated, such a finding would serve as an important reference point for future research in musicology and psychology. Furthermore, an analysis of the unique musical experiences of the participants has highlighted the distinctiveness of each of our subjective experiences with music. The extensive variability of experiences in response to music that the participants in this study reported reveals that we still have much to learn about each of our unique interpretations of musical stimuli.

This study was made possible by the generous contributions of the thirty-five synesthetes and AP possessors who agreed to participant in this study. Their participation enabled a vast amount of information to be collected through an online questionnaire, semi-structured world-view interviews, and synaesthesia and AP test batteries. The richness of this data highlighted the complexity of each individual case, with all participants experiencing different permutations and configurations of various forms of synaesthesia and AP. How, then, can these complex and idiosyncratic results be globally interpreted?

Unpacking this data in detail exposed numerous underlying themes, while also revealing the highly idiosyncratic nature of the experiences of participants in this study. Indeed, no two participants experienced their conditions in the same way, nor reported the same effects of their conditions on their musical development and current engagement with music. But if the lens is drawn right back, what becomes apparent is that underlying these highly individualistic reports is a common experiential mechanism. Drawing on the complexity of the data collected, my interpretation of this common mechanism resulted in the development of a speculative theoretical model. I conjecture that while this model can be used to describe the unique participant sample of this study, it might also be applicable to the musical development of non-synesthetes or AP possessors.

9.1. An Experiential Feedback Model of Musical Development

The results of this study suggest an experiential feedback model (EFM) of musical development that can be used to elucidate how the brain functions as an information processing system. The process begins at an experiential level, triggering cognitive and affective responses (internal locus). The synthesis of these internal cognitive and affective responses subsequently generates behavioural outcomes (external locus). External behavioural manifestations are then internalised as an experience, which subsequently provides feedback at an experiential level to the cognitive and affective domains, thus completing the feedback model. Once this flow of information is activated, the feedback process is thus continuous (see Figure 9.1). Within this model, and based on what the results of this study suggest, information flow therefore starts at an experiential level.

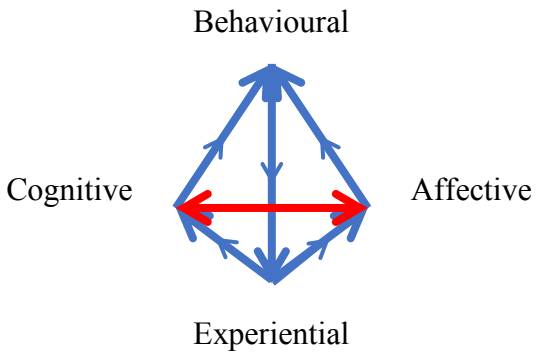

Figure 9.1. Kite formation modelling the experiential-cognitive-affective internal process, and behavioural external output. The reciprocal feedback cogitation between the cognitive and affective domains represents a continuous dialogue, which is influenced by further experiential feedback. This internal process induces behavioural manifestations, which in turn produce this experiential feedback.

The lower triangle of the kite formation of Figure 9.1 represents the internal process, bounded by the experiential, cognitive, and affective domains, with the apex of the kite expressing the external output. There is constant internal cogitation between the cognitive and affective domains, with behavioural outputs continuously providing feedback at an experiential level within the internal process (lower triangle).

The process of the EFM can be broken down into three stages (see Figure 9.2). Sensory information (SI), such as pitch or other music-related synesthetic inducer, enters the system and is processed by the brain to become a perceptual experience (PE). The flow of information commences at this experiential level, providing input to the cognitive and affective domains (step 1), which in turn influence behaviour (step 2). Behaviour is then registered in the brain as an experience, which subsequently provides feedback at an experiential level to the cognitive and affective domains (step 3). This loop is continually activated.

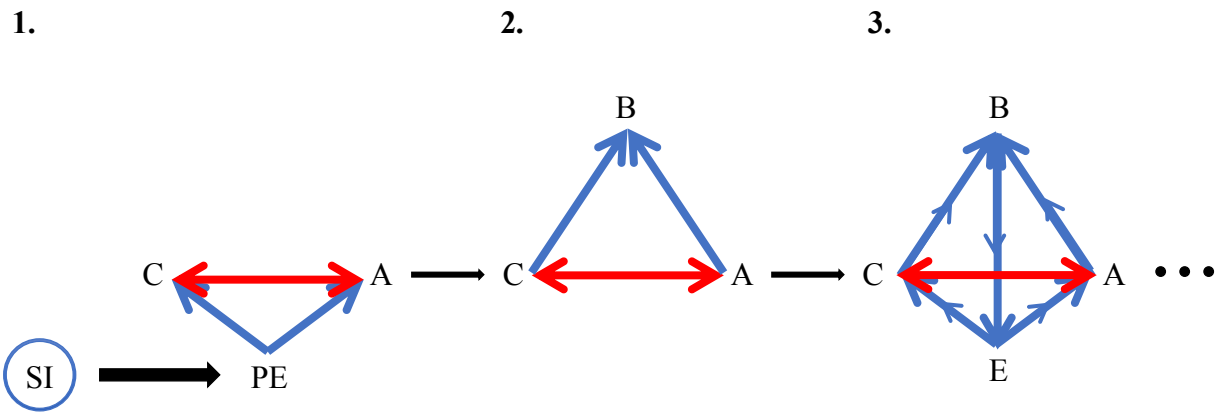

Figure 9.2. The three steps to music processing within the EFM: 1. Sensory information (SI) is processed in the brain as a perceptual experience (PE). This experiential level provides input to the cognitive and affective domains (C and A); 2. The constant cogitation between C and A invoke a behavioural output (B); 3. Behaviour provides feedback at an experiential level (E), thus activating a continuous flow of information and feedback processing.

As this model of information processing is designed to represent the perceptual experiences of a distinct group of musicians, the question then becomes: is the mechanism outlined above unique to this exceptional group of musicians, or is it a universal mechanism, common to us all? This question will be addressed in the following sections.

9.1.1. Are Synesthetes and Absolute Pitch Possessors Differently Packaged Individuals?

Synesthetes and AP possessors undeniably process musical stimuli differently to non-possessors. Referring back to Figure 9.2, it is clear that the auditory sensory information (SI) received by synesthetes, AP possessors, and non-possessors is the same. Where the differentiation initially occurs is in how the brain processes this information as a perceptual experience (PE). From the perspective of this study, sensory input refers to a pitched sound, or other music-related synesthetic inducer (such as instrument timbre, tonality, interval, or notated music). Differentiation

commences at an experiential level, where the brain generates an individual perceptual experience of the inducer, including concurrents (such as colour, imagery, taste, tactile, kinaesthetic, or note label). The perceptual experience of the same initial sensory information (inducer) is therefore multifaceted, leading to an increase in complexity and information flow.

While differentiation initially occurs at an experiential (perceptual) level, this differentiation continues within the cognitive and affective domains, which receive information concerning the perceptual experience of the sensory inducer. As has been reported in this study, these perceptual differences impact various aspects of cognitive and affective processing. Synesthetes and AP possessors therefore also differ from non-possessors in how this perceptual information is processed at an initial level of computation (C and A domains).

The distinctive processing of perceptual information at a cognitive-affective level provokes the differentiated behavioural outputs (B) of synesthetes and AP possessors that were reported in this study. As depicted in Figure 9.2, individual behaviours provide feedback at an experiential level, thus completing a continuous feedback process. This experiential feedback model therefore produces the differentiated behaviours of synesthetes and AP possessors reported by participants in this study.

Temporally, synaesthesia and AP occur across the lifespan, and thus exert a lifelong influence. Indeed, all of the synesthetes and AP possessors reported their initial memories of synesthetic percepts or heightened pitch perception occurred at a young age. The continuous reinforcement or reiteration of differentiated behaviours during

sensitive periods of increased neuroplasticity thus enhances the magnitude of this process, as the constant repetition of a particular behaviour subsequently develops into a behavioural pattern. Over time, the experiential feedback of this pattern is embedded in a synesthete or AP possessor's identity and worldview, substantively modifying them from what could be characterised as 'normal'. Once engrained, this identity and worldview are stable, being sustained by the continuity of the system. This explains why the continuation and stability of the synesthetic and AP experiences of participants was repeatedly reported as being fundamentally important to them, as they were intrinsically aware that the loss of their condition would interrupt this process. Ultimately, this interruption would have an adverse impact on the entire feedback model of their musical development: at experiential, cognitive, affective, and behavioural levels.

9.1.2. Are We All The Same?

While the music information pathway of synesthetes and AP possessors is notably more complex than that of non-possessors, the architecture and dynamism of the system is *not.* Synesthetes and AP possessors perceive musical stimuli differently to non-possessors, but non-possessors process musical information by employing the same underlying system. As noted above, differentiation between possessors and non-possessors begins at an experiential level, with an increase in information complexity occurring at this point. Yet individual differences that occur across all populations, such as personality and intelligence, operate within this model. As such, similar experiential information will be processed differently on a cognitive-affective level by each individual, leading to idiosyncratic behaviours. Individual differences in both internal and external environments help explain why synesthetes and AP possessors

exhibit both highly collective and also highly idiosyncratic cognitive, affective, and behavioural outcomes.

It is worth mentioning here the empathizing-systemizing theory developed by Baron-Cohen (2003, 2009), which suggests that individuals can be categorised as either empathisers or systemisers, according to how well they score on measures testing people's strength of interest in empathy and systems. Within the field of music psychology, these measures have been demonstrated to explain individual differences in music empathising and music systemising (Kreutz, Schubert, & Mitchell, 2008). Within the EFM, a left heavy (cognitive) versus right heavy (affective) feedback loop could be suggested as operating in individuals that exhibit a cognitive (or systemising) processing style, and vice versa. These differences in weight given to either the cognitive or affective aspect of the feedback loop would engender variances in reported emphasis in music perception, as well as differentiated behavioural changes. This assertion, however, remains speculative.

9.1.3. Summary of the Experiential Feedback Model

Synesthetes and AP possessors form a distinct and exceptional group, yet they experience the same degree of within-group variation as would be expected in the non-possessor population. They are therefore both unique, and the same. The EFM outlined above is suggested as an explanation of the complexity of this situation. The possession of synaesthesia or AP underlies how possessors function in different ways, at experiential, cognitive, affective, and behavioural levels. The basic mechanisms of this process, however, are the same for all individuals, regardless of whether they are possessors or not. Therefore, the processing modality of the system is the same for

both possessors and non-possessors. For synesthetes and AP possessors, however, there is a greater complexity of information processed by the brain at an experiential level. Ultimately, the unique perceptual experiences of synesthetes and AP possessors develop longitudinally into enhancements in creative cognition, including visualisation, concept formation, categorisation, and memory. Over time, these conditions can substantively modify the identity and worldview of synesthetes and AP possessors. Behavioural changes (both enhancements and impediments) are therefore the resultant outputs of a complex and continuous feedback model of musical development.

9.2. Significance of the Findings

Examining the multimodal musical experiences of synesthetes and AP possessors has provided a unique perspective on music and the human condition. This study has charted previously unexplored territory, and enhanced understandings of musicality, creative cognition, and musical affect. The major findings of this study demonstrate that music information processing is a multifaceted, multidimensional, and multisensory experiential phenomenon. Furthermore, this study has enhanced our understanding of the ways in which we perceive and respond to music, and of the cognitive and affective processes that support musical behaviours and underlie music perception, aesthetics, and emotion. The power of music to elicit strong emotional responses in listeners is thus contingent on each individual's unique interpretation of the sounds they are perceiving. It is hoped that the findings outlined in this dissertation will inspire others to further investigate individual psychological processes that shape music cognition and affect, while advancing discussions of the many varied questions concerning how learning and development interact with

psychological and genetic factors to lead to the full range and magnitude of musical experiences.

9.3. Final Personal Reflection

The EFM is intended as an assumption to generate further research, as what this study has highlighted is that there is still much more to uncover about the lived-world experiences of people with synaesthesia and AP. In the final section of the Discussion chapter (Chapter 8.3: 'Future research'), four potential future research topics were proposed. Of these, the third topic – 'The Impact of Synaesthesia and Absolute Pitch on Musical Development During Childhood' (Chapter 8.3.3) – acquired a more personal significance for me during the final year of my doctoral studies.

One afternoon, my then 11-year-old daughter was discussing her number preferences with me. Curious, I asked her if she saw colours with numbers. She looked at me oddly before pronouncing, "No?". Without knowing why, I proceeded to ask her if she ever saw colours with music. With eyebrow raised, she replied, "Obviously with music!" I was startled: after more than a decade spent researching the condition, I had failed to detect that one of my own children was experiencing music-induced synesthetic percepts. After this incident, we proceeded to have numerous conversations concerning the colours and images she experiences when listening to music or watching movies.

Fast-forward several months, to when my then 8-year-old son looked at a cover of a book I was reading and asked: "Syn-aes-the-sia. What does that mean?" I gave him a brief description, including the example of people who see colours when they hear

music. Comparable to his sister, he responded, “Oh I see colours! But you have to close your eyes.” I asked him to describe these colours for me, so he went to the piano, closed his eyes, and played: “I see little patterns, like swirls, and they change colours.” Again, further conversations ensued. While my remaining daughter and son are too young to be questioned, I am curious to know if they too experience music in a similar way, and how these experiences impact all of my children’s musical developments on cognitive, affective, and behavioural levels.

My research career began with the desire to comprehend my own strong experiences with music; it has now evolved to inadvertently include the desire to elucidate the multisensory musical experiences of children, such as my own.

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Appendices

Appendix A.

Participant Synopses

This appendix presents a synopsis of each of the 35 participants in this study. These synopses include demographic information obtained from the online survey, as well as key points from the one-on-one interviews. In the following discussion, all participants are assumed to be native English speaking and right-handed, unless otherwise indicated in the opening background description. The synopses are ordered according to the condition(s) of the participants:

A.1. Participants with both synaesthesia and absolute pitch (or quasi-absolute pitch)

A.2. Participants with synaesthesia

A.3. Participants with absolute pitch (or quasi-absolute pitch)

Each synopsis is headed with a table, which provides information concerning the condition(s), principle instrument, initial instrument, age of commencement of formal musical training, age at time of interview, and gender, of each participant. All participants names are pseudonyms. A tabulated overview of the demographic details is presented at the end of the synopses (see A.4).

A.1. Participants with Synaesthesia and Absolute Pitch or Quasi Absolute Pitch

1. James

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
✓	✓	Voice (Baritone)	Piano	7	18	M

James is a baritone, and a first year Bachelor of Music (Performance) student studying voice performance. He began formal voice training at the age of 14, however his earliest formal musical training was on the piano at the age of 7. He also plays the viola. James was diagnosed with autism spectrum disorder and with a speech disability at the age of 2, which necessitated speech therapy between the ages of 2-4.

James has AP, and also mentioned on the questionnaire that he was unsure as to whether or not he had synaesthesia. During the course of the interview he was nonetheless able to describe the colour associations he has recently started to make, and it was subsequently agreed that he should sit the online synaesthesia test battery. This he did, and was positively diagnosed for synaesthesia. Two central associations were mentioned. First, James described how he has developed what he believes to be a form of key signature→colour synaesthesia. James mentioned five keys that he specifically associates with stable colours, while the other keys can also have colour associations, although these tend to fluctuate. James also associates colours with individual notes, and these are the same colours to those he sees for the corresponding keys. These types of synaesthesia only began to appear last year, during James's final year of high school. Second, James described a more recent occurrence of both musical sound→colour and musical instrument sound→colour synaesthesia, where different instrument groups, such as brass or strings, have different perceived

corresponding colours. This second type occurred this year, soon after his entry into the Conservatorium. What is certain is that James's AP ability considerably predated his recent acquisition of synaesthesia. As well as these music related forms, James also describes experiencing elements of mirror-touch synaesthesia, were he feels an increasing sensation of heat when he sees people engaged in physical contact. This feeling occurs throughout his whole body, but particularly up and down his spine.

While discussing the question of his acquired synaesthesia, James mentioned an interesting sensation he feels, where he perceives speed of music and pitch to be related. As such, his general mood or the time of day can affect his pitch and movement perception. For James, if a piece of music sounds slightly higher in pitch, he perceives this as also slightly increasing in speed, and vice versa. James also mentioned that he has a strong preference for four of the musical keys, and that these were the keys that he has developed the most stable colour associations for. Furthermore, if a piece is transposed from a preferred key into a key that he dislikes, this can engender a strong negative physical reaction for him. This is particularly true for transpositions from C# Major to C Major: a key that he finds bland and boring.

James was a highly engaged participant who delivered his answers fervently and with a strong sense of conviction. It was clear that this is a subject he is passionate about, and he gave detailed and reflective answers.

2. Mason

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
✓	✓	Violin	Piano	6	20	M

As a second year Bachelor of Music (Performance) student, Mason's principle instrument is the violin, which he began at the age of 8, while he also plays the piano, on which he began his formal training at the age of 6. Mason was born in Australia to Russian parents, and while English is now his primary language and the only language he speaks fluently, he exclusively spoke Russian with his parents for the first three years of his life. Mason has an older brother who does not have AP, yet possibly has synaesthesia, as conversations between Mason and his brother seem to indicate. Mason is also a distant relative of the pianist Sviatoslav Richter, who is also known to have had AP, and is thought by Mason to have had synaesthesia.

Mason has both AP and multiple forms of synaesthesia. Specifically, he has a rare case of multimodal synaesthesia, where musical notes, tonalities, and instruments induce both colour and taste percepts. Mason also has object personification, and vision→smell, orgasm→colour and pain→colour synaesthesia. He is an associator synesthete, and both his colour and flavour percepts are experienced internally. Remarkably for his young age, Mason observed that his synesthetic percepts are getting weaker with age. He remembers a peak in his synaesthesia at around the onset of puberty, and a gradual diminution in intensity since then.

During the interview, Mason commonly used the second person to explain his experiences. This uncommon language use was further highlighted by his use of ambiguous response types, such as "probably" or "usually not", instead of definitive

answers such as yes or no. This made secondary questioning imperative, but even so, he was often unwilling to give definitive answers, even after being directly questioned. This did not seem, however, to be due to his inability to do so, but more to do with the reflective nature of his responses, emphasised by the lengthy time he often took to respond to questions, which were frequently punctuated by long silences. While his awareness of the influence of his synaesthesia and AP on certain musical tasks was evident, it was also clear that many of the questions asked were novel for him, and therefore required a higher level of introspection. The interview was subsequently prolonged, but throughout the process Mason remained focused.

3. Ella

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
✓	✓	Composition	Piano	4	24	F

While Ella is a second year Bachelor of Music (Composition) student, her principle instrument is the piano, for which she began formal training at the age of 4. She also plays the violin, viola, drums/percussion, and guitar. Ella has an older sister with AP, and while both learnt music from an early age, only Ella has gone on to become a professional musician. Ella's mother is originally from Vietnam, and Ella's maternal language was therefore Vietnamese, which she learnt alongside English as a child. After entering Kindergarten however, she ceased to speak Vietnamese on a regular basis, and now does not consider herself to be a fluent speaker.

Ella has both AP and synaesthesia, and is an associator synesthete. While initially unsure as to whether what she was experiencing could be classified as 'synaesthesia', we were able to ascertain during the interview that she was indeed a synesthete, and

this was confirmed by the online synaesthesia battery test. Ella experiences colour and textural percepts with musical notes, and also describes how these percepts can be modified based on the instrument being played. She does not experience specific colours with musical keys, but does see a juxtaposition of the colours of individual notes contained within a chord or harmonic progression. Although admitting to finding it "weird", Ella associates the white notes of the piano with ascending numbers, starting with C = 1, until B = 7. She does not believe that she was ever taught this association, but does feel that this connection is strong. Ella has only recently discovered a separate association that she experiences, namely kinetics→sound. She describes that when watching moving images in silence (such as a movie with the sound turned off), she 'hears' rhythms, such as those played on pitched drums. These sonic impressions are automatic and involuntary, and she herself remains perplexed as to why she is unable to control their occurrence.

At the completion of her interview Ella mentioned that she is also a visual artist, and that although she has never created a piece of art to visually represent the synesthetic perceptions of her musical compositions, this is a creative task that she is interested in pursuing in the future. She remains unsure, however, if viewing her artistic creativity as an integral part of her life is tied in with her synesthetic colour associations. In comparison, she clearly acknowledged during the interview that being a musician is indeed a fundamental part of her personal identity, and that she feels that her synaesthesia and AP abilities are not only important to her musicianship, but that they are abilities she was born with.

4. Xavier

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
✓	✓	Violin	Piano	5	22	M

As a first year Diploma of Music (Performance) student, Xavier's principle instrument is the Violin. He started his musical training, however, on the piano at the age of 5, before commencing violin at 7. Xavier also plays the drums. Before auditioning for the Conservatorium, Xavier completed a degree in Engineering. He acknowledges that his synaesthesia was a major factor in his decision to ultimately pursue a career in music.

Xavier has both AP and synaesthesia. He is an associator synesthete with multiple forms of music related synaesthesia, in particular musical key→colour and musical note→colour forms. For Xavier, the colour of unfamiliar music may change depending on which key he believes the music to be in. Enharmonically equivalent keys induce different colour percepts, highlighting the importance of the graphemic label for his synesthetic percepts. Xavier also experiences colour percepts with non-musical sounds, but only when a pitch or pitch range can be detected. While he does not associate colours with individual instruments, he does indicate that changes in register affect the underlying colour expressed by individual notes or chords. Another highly unique factor which influences his synesthetic colour percepts is the weather, whereby sunny and warm days will make them appear brighter, while cold weather will make them appear darker and denser, both when playing and listening to music. His synesthetic percepts are also affected by his asthma, stress, general mood and emotional state, musical style, alcohol and marijuana consumption, and the specific pitch level or tuning system employed. In all of these cases, however, it is not the

colour of a specific key or tonality that will be affected, but rather the shade of that colour. Lastly, Xavier attributes colours to classification systems. In music, this translates into the assignation of colours to specific musical styles. This association is more generic, and while Xavier does see a colour when focusing on the style in question, it will not affect the colours seen when listening to specific pieces of music, which will retain their individual colours, based on their tonal structure.

While Xavier acknowledges that his synesthetic percepts are strongest when listening to music, he also experiences several other forms of non-sound related synaesthesia, including non-grapheme ordinal personification (where for Xavier each day of the week and month of the year has its own personality and colour associated with it), a latent form of alphabetic grapheme→colour synaesthesia (stronger as a child, but still present if focused on), kinetics→personality and personality→colour synaesthesia (which for Xavier translates as a strongly intuitive sense of an individual's energy or 'aura', including a colour component), and emotion→colour synaesthesia (where different emotional states trigger colour sensations for Xavier, particularly if he focuses on the emotions he is experiencing).

Xavier was a passionate and candid interviewee, who generously agreed to having a section of the interview videotaped. His was one of the longest interviews, due to the fascinating nature of his unique percepts. This in no way deterred Xavier from providing detailed and thorough responses for the duration of the interview.

5. Samuel

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
✓	✓	French horn	French horn	7	18	M

As a first year Bachelor of Music (Performance) student, Samuel's principle instrument is the French horn, for which he began formal training at the age of 7. Samuel was born in Hong Kong, and his mother tongue is Cantonese, while he also speaks Mandarin. He moved to Australia at the age of 10, and now speaks English fluently. Samuel suffers from episodes of severe depression, and these impact the intensity of his recurrent musical imagery. Samuel also suffers from a combination of costochondritis, sinus tachycardia and a back nervous problem, resulting in several hospital admissions to date.

Samuel has AP. When completing the online survey Samuel asserted that he did not have synaesthesia, however reading through the list of possible forms of synaesthesia uncovered several that stood out for him, and these were discussed during the interview. The experiences described by Samuel during this discussion can be categorised as emotion→sound synaesthesia and mirror-touch synaesthesia. Both of these are rare forms of synaesthesia, and are moreover untestable using the online synaesthesia battery test employed for this study. His tentative diagnosis was therefore made purely on the basis of self-report.

Emotion→sound synaesthesia is extremely rare, particularly as it proceeds divergently to the typical directionality of most forms of synaesthesia (where sound is the inducer, not the concurrent). For Samuel this translates as musical imagery induced by reading or hearing words associated with emotions, or by thinking about

or feeling particular emotions. Because by his own admission he has trouble expressing his own emotions, he describes hearing them as sounds and music. This internally generated and perceived music is involuntary and stable, although heavily affected by his own emotional state, and current degree of anxiety or depression. Although as vivid as external music, Samuel hears this music in his 'mind's ear', and as such would classify as an associator synesthete. As for his mirror-touch experiences, Samuel describes these as being exclusively emotion-mediated, and focused on tickling. When seeing someone being tickled he himself experiences the physical symptoms of being tickled: a sensation he finds highly disagreeable. He experiences a weaker form of this when watching intimate physical contact, such as kissing.

Samuel mentioned finding it challenging to discuss his emotions, and this was perceptible during the interview. It was equally clear that he found it difficult to communicate in a detailed way, and needed prompting to clarify his statements and provide more substantiated responses. He was, however, very receptive to discussing complex issues regarding his mental and physical health, as well as his personal inner imagery. While he did not appear to react when advised his unique perceptions were potentially synesthetic, he did emphasise the importance he places on his musical imagery and interrelated musical memory, accentuating the panic he would feel if he were to lose them. He believes he was born with AP, and that his musical training has enabled him to retain and develop this ability.

6. Benjamin

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
✓	✓	Musicology	Piano	3	23	M

As a second year Master of Music (Musicology) student, Benjamin's principle instrument is the piano, for which he began formal training at the age of 3. Benjamin also plays the harpsichord, pipe organ, and baroque recorder. After having a nervous breakdown at the age of 12, which left him hospitalised for a lengthy period, he was diagnosed with anxiety and depression, for which he is currently under treatment. He was subsequently diagnosed as being on the autism spectrum (Asperger's). Benjamin did have seizures during this same period leading up to his hospitalisation, however he does not have epilepsy. Benjamin is left-handed.

Benjamin has AP, and two types of synaesthesia. The most prominent of these is musical key/tonality→colour. Colour is induced by musical keys both when he listens to and plays music, and also when looking at a score. The colours he sees when reading notes on a page are not, however, due to reading the written form of the note, but rather due to his internal hearing of the notes he is reading. This is only possible because of his AP ability, which is combined in this instant with his synaesthesia. Benjamin also has colour percepts for individual notes, but again these are heavily linked to the tonalities for which they are the tonic. The second, and weaker, form of synaesthesia that Benjamin exhibits is ticker-tape. This only occurs in stressful social situations, where Benjamin will see the script of his conversation written out and floating in front of his eyes, while still being situated in his mind's eye. For both forms of synaesthesia, Benjamin is an associator synesthete.

Benjamin had initially been reticent about the prospect of participating in this study. While he had previously heard of synaesthesia, observing a postgraduate seminar presentation of mine mid-way through my PhD engendered the realisation for Benjamin that what he was experiencing could potentially be synaesthesia. This was a moving realisation for him, and he subsequently decided to participate, with the hope of learning more about his unique perceptions. Benjamin did admit to being "quite nervous" about the interview. During the interview Benjamin spoke candidly about the persistent bullying he endured as a child from other school students, and notes that his superior musical achievements were a decisive factor in why he received that unwanted attention. This bullying not only contributed to his breakdown, but also to his decision not to touch the piano, quit practice and completely disengages himself from music in general for a full year during this dark period. He was nevertheless able to resume his musical journey through willpower, and with the gentle coaxing of his mother to steady him.

Benjamin was emotional during the interview, but the process of talking for the first time about the potency of his relationship with AP was cathartic for him. He is only now coming to terms with the immense strength of this relationship. Benjamin was visibly distressed by the possibility his AP ability would weaken with age, and presumed he would experience this loss of ability as a "death".

7. Matilda

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
✓	✓	Saxophone	Piano	5	18	F

As a second year Bachelor of Music (Performance) student, Matilda's principle instrument is the saxophone, for which she began formal training at the age of 11. Her earliest formal musical training however was on the piano at the age of 5, while she also plays both the guitar and the bass guitar. Matilda is the eldest of three siblings: all three have synaesthesia, while only Matilda and her younger brother have AP. Interestingly, both AP possessors - Matilda and her younger brother - have pitch→colour synaesthesia among other forms, while her sister does not have any music→colour form (although she has other forms), and does not have AP. It is unclear if there is any meaning to this, or if there is a relationship between pitch→colour synaesthesia and AP in these cases. What is more, Matilda believes her synaesthesia, and that of her brother, are "stronger" than what her sister experiences. Matilda has been diagnosed with depression, and in particular describes a 6-month period last year when she found herself in a situation of financial and mental hardship. During this period she indicates she lost her feeling of engagement with the world, and that as a consequence of this her synaesthesia and AP were both dulled, with all of her synesthetic colours taking on a shade of grey.

As well as her AP, Matilda has several music and non-music related forms of synaesthesia. She is an associator synesthete. Her earliest recollection involves coloured days of the week, while she also experiences a weaker form of coloured months of the year. Matilda describes how the colours of the days of the week can influence her choice of activity on specific days. She acknowledges, however, that

some of the colours she associates seem wrong. In particular, the colours of the weekend are grey and black, and she admits this does not make sense to her. Although these grey and black concurrent percepts are only seen with her mind's eye, they strongly impact her ability to be positive about these days, which she would otherwise potentially see as the best days of the week. Matilda also has grapheme→colour synaesthesia, as well as musical note, pitched general sounds, and tonality/key→colour synaesthesia. These pitch centred forms of music-related synaesthesia are mediated by the amalgamation of her coloured graphemes with her AP ability. As such, the colours she associates with individual notes, as well as their corresponding tonalities, are identical to the colours she associates with the alphabetic equivalent of their pitch label. Her ability to label each individual pitch is crucial to her ability to internally see a corresponding colour, and Matilda thus believes that her music related forms of synaesthesia are heavily reliant on her AP ability. Finally, Matilda sees colours when reading musical notation on a score, contingent on her AP-induced audiation of the music she is reading.

During the interview Matilda admitted to actively aiming to reduce the impact of both her AP and synaesthesia on her life in general. She became cautious after hearing and reading stories of the potentially negative impact these conditions could have, and firmly believes it is imperative for her to retain control of her mental state. That said, she regards both conditions as positive and helpful aspects of her life, and would not want to be without either of them.

8. Olivia

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
✓	QAP	Composition	Piano	10	48	F

While Olivia is a fourth year Bachelor of Music with Honours (Composition) student, her principle instrument is the piano, for which she began formal training at the age of 10. Olivia understands that one of her sisters and her paternal grandmother have AP. Both of these family members are professional musicians. She also believes her son may potentially have a form of synaesthesia involving colours and patterns, but points to his young age as a factor in her hesitation to give a definitive answer regarding his self-reported perceptions.

Olivia came into the interview unsure if her perceptual experiences constitute forms of either synaesthesia or AP. After consultation with her it was determined that she has a weak form of synaesthesia, and associates colours to sounds, musical notes, musical keys, and specific instrument timbres. Olivia appears to be an associator synesthete, but it is unclear if she should be classified as an associator that sees or as an associator that knows; i.e. it is unclear whether she sees her associated colours in her mind's eye, or whether she simply has associated colours without necessarily seeing the colour. Olivia does not have AP, but did fall within the QAP range when semitone errors were counted. This would be an acceptable option in her case, due to her age, and she therefore qualified as having QAP. Although weak, her music related synaesthesia is linked to her pitch ability. While not all musical keys have stable colour associations, some do, and her knowledge of the key being played reinforces the colour perception she is experiencing. Aside from these weak music related forms of synaesthesia, Olivia does have what appears to be a strong form of ticker-tape

synaesthesia, where she regularly sees words and how they are spelt - particularly those that she is about to write down - appear in her mind's eye as subtitles, and uses this image as a spelling and writing tool. She can also visualise in writing what someone is saying when they are speaking with her, but this does not occur with everybody or in every situation.

During the interview Olivia admitted that whether she did or did not have synaesthesia and/or AP was not a "big deal" for her, because since what she perceives is not strong it does not affect her in any real way. She does, however, feel that both her AP and synaesthesia are in constant development, despite her age, and that this development is due to her ever increasing exposure to music and music theory. As a composition major, she is hoping to explore the potentially beneficial effects that she believes these two conditions could bring to her creativity.

9. Mia

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
✓	QAP	Voice (Soprano)	Violin	7	19	F

Mia is a soprano, and a second year Diploma of Music (Voice Performance) student. She began formal voice training at the age of 9, while she has also been singing in a choir since the age of 6. Her earliest formal instrumental training was on violin at the age of 7. Although Mia's mother grew up in Australia, she is of Chinese (Hong Kong) background. Mia, however, does not speak Cantonese.

Mia has both QAP and multiple forms of music related synaesthesia, including general sounds→colour, musical key/tonality→colour, musical note→colour, and

musical instrument→colour. These forms can overlap, which can be confusing for her. Apart from colours, Mia often uses tactile metaphors such as velvet, pointy, sharp, and a "scrunched up crisp packet kind of feel" to describe the texture of the percepts she is experiencing. While she does not physically feel these textures, she is none the less adamant that these metaphors, which give an idea of the sensation rather than an actual experience of it, are helpful in describing her synesthetic percepts.

During the interview Mia discussed how note production is central to her QAP ability, and that singing the note – either out loud or in her head – is an important tool that she uses to label the majority of the black notes, for which she has a much less well defined ability. This emphasis on note production was evident during her AP test, where she hummed or sang each individual note as it was played to her. Although other participants would occasionally hum certain notes under their breath during the AP test, she was the only one to do so systematically and at a considerable volume.

Although Mia has both QAP and synaesthesia, she feels that her QAP is the dominant condition, and that while she believes her QAP would exist without her synaesthesia, the opposite would not be true. She admits however that this relationship is not certain and remains hypothetical, especially as she cannot remember which condition was chronologically first.

10. Chloe

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
✓	QAP	Composition	Piano	6	54	F

As a member of the Conservatorium of Music's professional staff (Senior Lecturer), Chloe's principle disciplines are composition, musicology, and performance. Chloe began formal musical training on the Piano at the age of 6, after having actively campaigned for over two years to be given lessons, for which her parents eventually conceded. She has one brother who she suspects has an undiagnosed case of autism.

Chloe has both QAP and synaesthesia, specifically grapheme→colour, musical note→colour, and time units→colour (days of the week) synaesthesia. She is an associator synesthete, and only experiences these percepts in her mind's eye. Her earliest synesthetic memory dates back to when she was 3 years old; yet she was not aware that what she was experiencing was synaesthesia until she heard a speech I gave shortly before the interview was conducted. This speech was the catalyst for her desire to partake in this study and was classified by her as the most powerful and revelatory experience she had had to date concerning her inner associative perceptions. Chloe labels the colours she sees as "phantom" colours and finds them very difficult to describe. She defines them as blended hues, or blended auras of other colours. She does, however, admit that they are consistently either "warm" or "cold". Chloe also believes that the colours associated with musical notes are grapheme-oriented and take on the same colour as here graphemes. She also only sees the colours when she internally thinks of and hears the notes, and never when she hears the notes externally played.

Chloe describes her QAP ability as unreliable, as it can be negatively affected by mood or fatigue. She considers labelling notes, particularly on the piano, easier than producing them, and attributes this to the fact that she uses the timbrel qualities of individual notes on the piano as a guide. She ascribes different personalities and sometimes genders to individual notes, yet senses that these qualities are somewhat mutable. Chloe further mentions that she associates certain notes with the openings of certain pieces of music, and that these associations are used as a mnemonic device.

Chloe had been initially invited to join the study but had at that time declined to participate. This decision was reversed after attending a presentation I gave, after which she volunteered as a participant. Although she did attempt it, Chloe was unable to complete the online synaesthesia test. She described the test as "very frustrating" and found it too difficult to pin down her exact colour percepts. Beyond the requirements of the study, Chloe has continued to provide personal and professional support and has been in frequent contact with the researcher concerning either additional personal information of interest, or discussions of potentially valuable new research.

11. Grace

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
✓	QAP	Piano	Accordion	4	27	F

As a first year Diploma of Music (Performance) student, Grace's principle instrument is the piano. She started her musical training, however, on the accordion at the age of 4, before switching to piano at the age of 6. She now also plays the guitar. Grace was

born and grew up in China, and only moved to Australia recently. Her mother tongue is Mandarin, while she also learnt English in primary school.

Grace did not qualify as having AP, but did perform above chance, and has qualified as having QAP. If semitone errors were counted at equal weight, however, she would fall directly on the cusp of the AP range. What is curious in Grace's case is that she has an unusual distribution of correct and semitone errors, particularly in light of her age (thought insignificant for AP deterioration). She obtained the largest number of semitone errors within the group of subjects, coupled with the lowest rate of correct responses for the under 45-year-old group.

Grace also has synaesthesia. She associates tonalities and different registers to colours, while also admitting to occasionally making up stories to accompany the pieces she is learning and conjuring up images to go with those stories. She believes that when she does this she plays better: both technically (because she is more relaxed and not thinking of the technical aspects of the piece during the performance), as well as emotionally (as this enables her to bring out the "soul" of the piece through the story). It was difficult to ascertain whether Grace had genuine synaesthesia during the interview, and she was cross-examined several times to clarify her answers. In particular, she was asked if she was "seeing" the colours or only imagining them, to which she replied that she could sometimes see them. After the interview she undertook the online synaesthesia test battery, where she did qualify as a synesthete. Grace therefore displays an interesting amalgamation of what appears to be genuine synaesthesia and strong imagery: both visual and musical.

Grace believes her synesthetic ability is still developing. One example of this continuing development is demonstrated by her conscious decision to start highlighting sections of her music just one year ago, as she felt it helped her understand the music. She described that when she asked herself which colours she should use, the colours came "naturally". Grace supplied the interviewer with scans of several pages of her highlighted scores, as discussed during the interview. These scores are a valuable resource, and demonstrate the process she goes through when learning, analysing, and memorising music.

A.2. Participants with Synaesthesia

12. Charlotte

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
✓		Flute	Flute	7	23	F

As a second year Master of Music (Performance Teaching) student, Charlotte's principle instrument is the flute, for which she began formal training at the age of 7. Charlotte also plays the clarinet. She has been diagnosed with and is currently under treatment for clinical depression, anxiety and OCD.

Charlotte has multiple forms of synaesthesia. Primarily, she has all of the sound-induced forms of synaesthesia where the concurrent is colour. This includes both musical and general sounds inducing colour percepts. Instrument timbre, tonality, pitch, and notated music all induce colour percepts, as do general sounds, including percussive noises and general non-pitched sounds. She does, however, indicate that her colour percepts are more dominant with musical sounds. As well as sound-

induced forms of synaesthesia, Charlotte has coloured orgasms, colour percepts induced by emotions, and personality→colour synaesthesia (coloured auras). Charlotte also has coloured days and months of the year that are located in specific spatial locations (spatial-sequence synaesthesia). Importantly, while the majority of Charlotte's inducers are sound and music related, the concurrents are systematically colours.

Charlotte is primarily an associator synesthete. There are three instances, however, where she experiences projected synesthetic percepts. The first of these is coloured musical scales, which she sees projected in bubble shapes in the space directly above her head. Charlotte very generously agreed to have part of the interview video recorded, enabling me to capture her gestures as she was indicating the form and location of these bubble shapes. This is the only instance of music or sound related synesthetic percepts being projected. The second projected form is spatial-sequence synaesthesia, whereby she sees the coloured days, weeks and months mapped out in front of her, in the same spatial location as her coloured musical scales. The third instance is her personality→colour synaesthesia, whereby she sees coloured auras surrounding people, especially those she is familiar with.

While she does not have AP, Charlotte believes that within certain conditions (including silence, a darkened room with no visual distractions, and no time restrictions), she may be able to use her synesthetic colour percepts to accurately label pitches presented to her in isolation. Charlotte did attempt the AP test, but scored at chance levels, therefore not qualifying as either an AP or QAP possessor.

During the interview process Charlotte was generous and forthcoming with her responses and appeared to be conscious of the effect of her synaesthesia on both her musical abilities and choices. She was not only eager to share her experiences but was also willing to divulge sensitive information relating to her medical history and sex-related synesthetic experiences.

13. Jack

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
✓		Composition	Percussion	12	27	M

While Jack is a first year Bachelor of Music (Composition) student, his principle instrument is the drum kit, for which he began formal training (percussion) at the age of 12. He also plays the piano, but is largely self-taught, and has difficulty reading music. Jack was diagnosed with Tourette syndrome in Grade 9 (aged 13), and also suffers from OCD. Although his tics have lessened with time, he admits to always subconsciously counting objects or situations, such as creases in the pavement. He also has two younger brothers with synaesthesia (grapheme→colour), and while both are musicians, only one works professionally.

Jack has grapheme→colour and certain types of music→colour synaesthesia and is both a projector and an associator synesthete. For his music→colour synaesthesia, his depiction of the induced colours as being indescribable suggests he may be experiencing 'phantom colours'. These colour percepts are clearly seen in his mind's eye, the defining characteristic of the 'associator' sub-group. The colours induced by graphemes, on the contrary, are projected approximately one foot in front of his face,

and Jack further describes these colours as “proper, tangible colours”, making a strong contrast to the music-induced ‘phantom colours’ he experiences inwardly.

During the interview Jack mentioned that he had never consciously used his synaesthesia as a mnemonic aid for the memorisation of music, but that this was a possibility he was interested in exploring. By the completion of the interview he also felt that his music→colour synaesthesia might subconsciously play a greater role in his musical decision-making than he had previously imagined. Jack recently released his first CD of original music and provided the researcher with details concerning the influence of his synaesthesia on not only the music itself, but also on the video clips that were produced to accompany several of the musical tracks. This information has been a valuable addition, which has enabled a greater understanding of the effect of synaesthesia on his work.

14. Ethan

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
✓		Piano	Piano	4	21	M

As a first year Bachelor of Music (Performance) student, Ethan’s principle instrument is the piano, for which he began formal training at the age of 4. Ethan also composes: an activity he indicated he is planning to develop through further tertiary study in the near future. Ethan has been diagnosed with and is currently under treatment for epilepsy, while he indicated he has also recently been experiencing a resurgence of CAPD (central auditory processing disorder), which he suffered from as a child. Ethan’s mother also suffers from epilepsy and is a synesthete, while his sister has a

mild form of bipolar disorder, and to the best of Ethan's knowledge has been recently diagnosed with schizophrenia.

Ethan has multiple forms of synaesthesia. He has all of the sound-induced forms of synaesthesia where the concurrent is colour, including both musical and general sounds inducing colour percepts. Interestingly, he notes that the induced colour percepts are far stronger when he is playing music than when he is listening to music or non-musical sounds. Ethan also has grapheme→colour synaesthesia and grapheme personification, as well as colour percepts induced by emotions, orgasm, pain, and temperature. One final and intriguing form of synaesthesia that Ethan has is a rare case of bidirectional synaesthesia, where not only do sounds induce colours, but under certain conditions colours also induce sounds. These induced sounds are experienced by Ethan as highly vivid and can block out external sound. This bidirectional form of synaesthesia is projected, while his other forms of synaesthesia are experienced as both associated and projected, depending on a range of different factors pertaining to each individual form of synaesthesia.

Ethan began the interview process by stating that this was probably the last synaesthesia or epilepsy study he would be doing for a long time, indicating that he had participated in quite a few studies, was tired of them, and found doing a lot of studies "frustrating". On questioning, however, it became clear that this was the first synaesthesia study he had participated in. It is worth noting that he was one of the first students to contact me directly and express his interest in participating in this study, and although free to terminate his participation in the study at any time, he remained engaged. At times during the interview Ethan made it clear that he was very tired, but

despite being asked several times if he wanted to stop or resume the interview another day, he insisted on continuing. Despite a certain level of irritation that he seemed to display from the outset of the interview process, he conceded on several occasions that the questions asked of him were novel questions he hadn't been asked before, and he was generous in sharing highly sensitive information, and giving his time in less than ideal conditions to complete the interview. It is also worth noting that several months after the interview Ethan approached me to enquire if he was able to volunteer to help with the data analysis of the present study, as he was interested in learning more about synaesthesia. His help was graciously refused, but I did offer to meet with him privately, and this meeting took place soon after to discuss synaesthesia in general, and Ethan's unique case, further. Despite multiple reminders spanning over a year, however, Ethan did not complete the online synaesthesia battery test, and we therefore do not have formal verification of his synaesthesia, and lack certain details concerning specific associations that he experiences.

15. Thomas

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
✓		Oboe	Oboe	13	19	M

As a first year Bachelor of Music (Performance) student, Thomas's principle instrument is the oboe, for which he began formal training at the age of 13. Thomas also plays the bassoon, flute, and saxophones, among other instruments. At the age of 7, Thomas was diagnosed with clinical depression, and is currently under treatment. His mother, his older brother and sister, and his aunt and uncle from his mother's side have also been diagnosed with depression. Parallel to this diagnosis, his older brother and his brother's daughter, his older sister and one of her children, and potentially

certain of his cousins, have all been diagnosed with autism spectrum disorder, while his older brother has also been diagnosed with schizophrenia.

Thomas has several forms of synaesthesia, primarily musical key/tonality→colour, musical note→colour, musical notation→colour, and musical instrument→colour. While individual notes do have specific colours, Thomas indicated that the timbre of the instrument playing the note would affect the perceived colour and form of individual notes, thus providing an excellent example of the interaction of different forms of synaesthesia. Thomas has specified that although, as a general rule, non-musical sounds do not elicit colour percepts for him, one notable exception is very loud noise which, regardless of its origin, will induce black and white static-like percepts. Interestingly, and parallel to his various forms of music related synaesthesia, Thomas also has the ability to draw and hold up numbers in front of him for a short period of time and uses this ability to calculate with up to six digits. These numbers are displayed in what he describes as "neon lights", and they move and wander within his inner visual space. Thomas is an associator synesthete.

Thomas's ability to "switch off" his synaesthesia as desired emerged as a central theme during the interview, which he emphasised as an important aspect of his synaesthesia. During the interview Thomas was soft-spoken, open to discussing his personal medical history, and highly accommodating. One notable example of this was his agreement to have one section of the interview video recorded, while he depicted the shapes made by different instruments through hand gestures and other physical movements.

16. Isabella

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
✓		Composition	Piano	5	20	F

While Isabella is a third year Bachelor of Music (Composition) student, her principle instrument is the piano, for which she began formal training at the age of 5. She also plays the violin. She has a cousin (male) with diagnosed autism spectrum disorder, and an uncle with Friedreich's ataxia. Both of these family members are from her mother's side.

Isabella has grapheme→colour synaesthesia. Both numbers and letters induce colour percepts, however the percepts for letters are stronger. This case of grapheme→colour synaesthesia has produced an interesting by-product for Isabella, in that she also experiences musical note or musical key→colour synaesthesia, exclusively if she is aware of the note being played (for example if she is playing the piano), or if she is aware of the tonality of a piece she is playing or listening to. Isabella does not have AP, and therefore does not see these colours unless she is aware of the tonality in question. As such, her colour percepts appear immediately when playing a piece, but may appear ulteriorly when listening to unfamiliar music. Once established, however, they are stable and constant. Isabella has experienced occasions of flavour→colour synaesthesia, but these occurrences are now rare and almost exclusively confined to her childhood. Days of the week and months are also coloured for Isabella, and projected in front of her on posters, although they do not have specific spatial locations. Rather, each day or month name can be interchangeably projected onto the same space. Apart from this one instance of coloured weekday and month names, Isabella is an associator synesthete, and sees the colours interiorly with her mind's

eye. She also has what she describes as a "slight" photographic memory, which she is particularly aware of in relation to musical notation on a score.

By her own admission, Isabella had rarely reflected on her synaesthesia, and had strong reservations concerning its function and advantages in her life, and especially for her music. During the interview process, this translated itself into a situation where questions that were asked of her were often initially answered in the negative, only for her to interject at a later stage with the sudden realisation that perhaps the opposite was true. As the interview progressed a deep realisation and recognition of the possible impact of her synaesthesia on her musical development evidently grew and constituted for her a real "eye opener" as to its influence not just in her everyday life, but also to her musical identity. She acknowledged that this revelation and heightened awareness of her percepts would be something that she would most certainly reflect on at a later stage, and furthermore, that she believed her synesthetic correspondences could be cultivated in a way as to be employed as a memorisation tool in the future.

17. Ruby

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
✓		Voice (Soprano)	Voice	5	22	F

Ruby is a soprano, and a third year Bachelor of Music (Voice Performance) student. She began formal voice lessons at the age of 5, and briefly studied flute as a child. Ruby felt the flute did not suit her, and "hated everything about it". She was always drawn to the cello, however, and began lessons at the age of 14. She admits that the synesthetic colours she associates with these instruments reflects her instrumental and

timbral preferences. Ruby is a person with albinism, is legally blind, and has photophobia. She is the youngest of four children, with one brother, and two sisters. Her closest sister age-wise also has synaesthesia, and they have discussed the differences between their percepts together. This sister is also a musician, as is her older brother. All three musician-siblings are people with albinism, while her remaining non-musician sister is not.

Initially, Ruby was unsure as to whether she had synaesthesia at all, and was therefore hesitant about participating in the study. She mentioned at the beginning of the interview that she thought I would be "terribly disappointed" by her responses, but by the end of the interview process it was ascertained that what she was experiencing could certainly be considered as synaesthesia. In the online questionnaire Ruby had listed several types of synaesthesia that she was unsure of possessing. During the interview it was established that she experiences multiple forms of synaesthesia with colour as the concurrent, including musical sounds and instruments→colour, pain→colour, days of the week→colour, and grapheme→colour. While she does not have colour associations with all graphemes, she does have strong and stable associations with many, and internally sees the written grapheme in its associated colour in her mind's eye. Ruby also attributes colours to certain people. As well as these colour-related forms, she also has grapheme personification for numbers (including gender), and ticker-tape synaesthesia, which she experiences intermittently but most often during dialogue when she is speaking out loud, and occasionally with her own internalised thoughts. While involuntary, Ruby can turn it off if necessary, and describes the words as sometimes scrolling in front of her, and sometimes fading in and out.

Ruby depicts her sound-induced synaesthesia as seeing "a transition in colours" when listening to music, particularly when she has her eyes closed. She describes experiencing a change in colour with different instruments or different registers of the same instrument, as well with different tonalities and musical styles. She is an associator synesthete and sees these colours in her mind's eye.

During the interview it was often joked that the questions being asked were novel and extremely difficult for Ruby to answer, reinforcing what Ruby had previously mentioned concerning the underwhelming nature of her synesthetic percepts. The interview was often punctuated by pauses, highlighting Ruby's need to reflect on the questions asked, many of which Ruby admitted to never having contemplated before. Although attempted, Ruby was unable to complete the online synaesthesia test due to her vision impairment.

18. Lily

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
✓		Voice (Soprano)	Cello	5	31	F

Lily is a soprano, and currently in her third year of a Bachelor of Music (Contemporary Voice Performance). Lily is left-handed. She began her formal musical training on the cello at the age of 5. Lily also plays an eclectic array of instruments, including the ukulele, guitar, electric bass, samisen, cavaquinho, and berimbao. While her initial instrumental lessons were on the cello, she also partook in parent-child musical activities with her mother from the age of 3. Lily comes from a family of professional musicians. Both her mother and father are singers and choral

conductors, with her father also being an organist, and her mother a university lecturer in music education. Tracing her musical lineage, Lily notes that both her mother's parents were heavily involved in music – particularly her maternal grandmother – and that on her mother's side all her aunts and uncles are professional musicians, and likewise all her cousins are musical. Lily's mother experiences coloured auras (surrounding people) and has grapheme→colour synaesthesia. Lily has never spoken to either her father or older brother about synaesthesia and is therefore unaware if either of them are affected.

Lily has multiple forms of synaesthesia and is an associator synesthete. While she does not experience automatic coloured auras like her mother, Lily does have grapheme→colour synaesthesia. For Lily, individual numbers and letters have colours attached to them in varying degrees of strength, but these colours do not blend when seen in words or compound numbers. Lily also experiences colours with phonemes, but these colours are intrinsically associated with the letters with which the phonemes are assembled. One form of synaesthesia for which Lily has only recently become aware is colour→smell, whereby if Lily is exposed to a particularly prominent and off-putting colour, she will experience a pungent and nauseating accompanying smell, occurring automatically and involuntarily. This rare form of synaesthesia is not just a recent occurrence, but has only happened a few times, taking Lily by surprise.

Lily has several music-related forms of synaesthesia. The first of these is musical instrument→colour where tone qualities that she dislikes have very strong colour associations. This is particularly true for the saxophone, which produces a horrible muddy yellow colour. Electric guitars also produce strong colours, and these elements

can affect her preferences relating to musical styles and instrumentation. Moreover, these disliked tone colours can leave Lily feeling physically sick. Lily also sees colours when she hears or reads musical intervals, but this is categorically because of the transfer of the colour she sees associated with the intervallic number. This is the same phenomenon that occurs for her with musical notes, where it is only when she knows the grapheme label of what she is hearing that she sees the corresponding colour in her mind's eye. As such, both of these latter forms of synaesthesia are examples of a transfer from the percepts of her grapheme→colour synaesthesia.

Lily considers herself to be an excellent sight-reader, and attributes this in large part to her ability to use her intervallic colours to map out the melodic contour. She also acknowledges using these colours to accurately navigate her voice or instrument, harmonically and chromatically, while improvising. This, she concedes, puts her at a distinct advantage.

A.3. Participants with Absolute Pitch or Quasi Absolute Pitch

19. William

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
	✓	Piano	Piano	7	20	M

As a second year Bachelor of Music (Performance) student, William's principle instrument is the piano, for which he began formal training at the age of 7. William also plays the flute, clarinet, and saxophone, as well as being an avid singer. William's older sister has been diagnosed with dissociative identity disorder as well as Type 1 diabetes, while his mother has Addison's disease.

William has AP. He was made aware of his AP at the age of 12 after a conversation with his then piano teacher but holds the personal belief that he was born with it, and expressed numerous times his conviction that his AP is a "gift". While discussing his musical memory, which he described as "very, very good", he mentioned he has an exceptional long-term memory. This is especially the case for what he terms "irrelevant" information, such as primary school roll calls and television ads.

During the interview process William was very open to discussing the positive effects of his AP on his musical identity. He readily disclosed that it defines who he is as a person, so much so that the possible future loss of his AP "terrifies" him. He also willingly shared personal information regarding painful bullying that began within his family and continued throughout most of his school years. The self-esteem that was generated by the knowledge of his "rare" ability during his final years in high school was a crucial turning point in his development, and a strong motivational factor in his decision to continue musical training. William was the first subject to express his interest in the study and continued to demonstrate his enthusiasm during the subsequent data collection stages.

20. Noah

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
	✓	Electric Bass	Electric Bass	10	18	M

As a first year Bachelor of Music (Performance) student, Noah's principle instrument is the electric bass, for which he began formal training at the age of 10. Noah also plays the French horn and guitar.

Noah has AP. While his initial understanding that his AP ability was unusual came from his teachers at about the age of 12, his earliest memories of his AP ability are from the age of 5 years old. This was considerably before he received any form of formal musical training. While Noah claims to not have synaesthesia, he does describe an interesting and synaesthesia-like association that he makes, where each musical pitch has a distinct personality. He first mentioned this on his questionnaire, under 'other' in the synaesthesia list question, and described the personalities of some of the pitches during the interview. He is not sure if they have genders but does concede that individual pitches definitely have distinct characters, and distinct sounds on their own.

Throughout the interview Noah remained nonchalant about his AP ability, and mentioned several times how he had initially thought everyone could name notes as he could. He believes that he was born with AP, as he has had it for as long as he can remember. Noah mentioned on several occasions that people tended to assume that he had it "easy", however he was adamant that for him, having AP is "no big deal".

21. Ava

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
	✓	Cello	Piano	2	20	F

As a second year Bachelor of Music (Performance) student, Ava's principle instrument is the cello, for which she began formal training at the age of 8. She also plays the piano. Ava's mother is a piano teacher, and she began piano lessons with her mother aged 2. Ava describes this situation as being one where she was able to read

music before she was able to read books. Ava has one sibling – an older sister – and she believes that both her mother and sister may have AP, although she is not certain of this, and has never directly asked them. While her father is a scientist, and does not play a musical instrument, Ava and her family have had suspicions of him being on the autism spectrum, but this remains speculative.

Ava has AP. While she does not remember a time when she didn't have AP, her earliest understanding that this was an uncommon ability came when she was in her early teens. Before this time, Ava had been under the assumption that everybody had this ability. Because of her highly musical upbringing, Ava finds the question of whether her AP ability is innate or developed over time to be a difficult one to answer.

Ava was an articulate and forthright subject, who evidently took great care in giving measured and calculated responses. Interestingly, while her initial interview responses were given in the first person, she often shifted to second person to explain her experiences once the questions were focused on her musical abilities, and how these were affected by her AP. While on the one hand Ava views AP as being an ability that is somewhat overrated within the music community, she none-the-less acknowledges the potentiality that her speed of development, enjoyment of music, and motivation to continue musical training, may all have been diminished had she not had this ability.

22. Emily

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
	✓	Piano	Piano	5	20	F

As a second year Bachelor of Music (Performance) student, Emily's principle instrument is the piano, for which she began formal training at the age of 5. Emily is a fluent Mandarin speaker yet considers English to be her mother tongue. Emily believes her older sister, who teaches piano, also has AP.

Emily has AP. When asked to describe how she is able to label individual pitches, Emily describes individual notes as having unique and distinct "colours". When cross-examined, she explained that she did not 'see' these colours, but that these individual note characteristics were not only present but were potentially the reason why she was able to label the notes. This emphasis on the special characteristics of individual notes was further expanded by Emily to include individual keys and chords, which she also perceives as possessing unique characteristics.

During the interview Emily described how she often thinks of pitches in fixed-do solfege, particularly when singing. She attributed this to the fact that she first began piano tuition using the Yamaha method, which incorporates a strong emphasis on fixed-do aural training. Emily was offered the choice to complete the AP test using solfege in place of alphabetic note names, but declined to do so, preferring to use standard note names.

23. Sophie

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
	✓	Musicology	Piano	5	30	F

While Sophie is a second year PhD in Musicology student, her principle instrument is the piano, for which she began formal training at the age of 5. Sophie is from Malaysia, and her mother tongue is Mandarin. She has a younger sister who has AP, however this sister is not involved with music on a professional basis.

Sophie has AP. While she feels that her AP is automatic, she described how individual notes have specific "textures", and that this enables her to distinguish between them. Although she uses the word 'texture' metaphorically, her reliance on multisensory representation is striking, particularly in her use of tactile and temperature-based metaphors. She did admit, however, to being unable to describe the exact characteristics of individual notes.

During the interview Sophie acknowledged that she sees her AP as a gift, in a spiritual sense, and attributes to it a very strong motivational impact on her desire to continue musical studies. Sophie commenced her tertiary education by completing an undergraduate degree in an unrelated field, before deciding to pursue music further. This change was, by her own admission, strongly influenced by her "gift". Sophie further mentioned that she believes AP has a genetic component to it, and that she was born with it.

24. Joshua

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
	✓	Composition	Piano	7	45	M

As a member of the Conservatorium of Music's professional staff (Senior Lecturer), Joshua's principle discipline is composition. He began formal musical training at age 7 on the piano and would also subsequently learn the oboe. He now considers voice as his principle instrument, as it is presently what he performs with most often. Joshua revealed that his father is a music critic, and that he was exposed to music in the home and at concerts from a very early age. Joshua has epilepsy, with seizures beginning in high school at about the age of 13. While he has never felt that the medication he takes for his epilepsy has in any way impacted his AP ability, he does mention that his wife – also an epileptic - has experienced a negative effect of the medication on her pitch perception, describing how her pitch initially dropped by a semitone. This effect diminished through continued exposure to the medication and has now stabilised. Joshua is left-handed.

Joshua has AP, which he describes as being a self-taught ability. This 'training' occurred between the ages of 12-15, by drawing on cues from familiar pieces of music, and by focusing on the distinct timbre of individual pitches on the oboe. He concedes, however, that there is probably an innate element to this, and that he may have developed AP even if he hadn't actively trained himself to do so. Joshua stated during the interview that he believes he would be more accurate in the production of specified pitches, rather than in their labelling, however he concedes that this is unverified.

During the interview, Joshua mentioned that one of the best things about having AP is the positive influence it has on his musical imagery, and the positive impact this AP enhanced imagery has had in facilitating his ability to compose. Indeed, Joshua feels that his aptitude for musical imagery is so important, that he rates it as the most valuable and enjoyable thing about having AP. Interestingly, he also mentioned that he "oddly enough" he often composes in cafes, where he feels that the background noise helps him concentrate and focus. Joshua was very focused during the interview process and gave highly precise and detailed responses to the questions asked of him. He demonstrated a high level of introspection, and responded candidly to all my enquiries, while also communicating the rationale behind them.

25. Lucas

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
	✓	Voice (Tenor)	Voice	17	19	M

Lucas is a tenor, and a second year Bachelor of Music (Voice Performance) student. While he previously had weekly singing lessons from the age of 15 at High School, he did not begin what he himself classifies as formal musical training until the age of 17, when he began his tertiary education at the Conservatorium. Lucas also had a brief period of piano lessons as a teenager, and later taught himself the guitar. His father, who is a professional musician, has AP. Lucas is left-handed.

Lucas has AP. While discussing the AP of his father, who is a professional cellist and music teacher, he acknowledged what he believes to be his "hereditary endowment", implying that his AP ability, and potentially his musicality in general, have been genetically passed down from his father. Lucas furthermore believes that he has had

the ability to distinguish frequencies and where those frequencies should "sit" relative to the others for as long as he can remember, but the arbitrary labelling of those frequencies was "developed" at a later stage of his life: in Lucas's case, in his late teens. He does not believe that AP can be achieved without first having a "natural sensitivity" to pitch, and that in his case the development of his AP has occurred naturally over the past few years, simply by listening to music. He indicated that he generally finds producing notes easier than labelling them yet was quick to insist that identifying pitches was never a problem if just a single note is played. Although Lucas specified that he does not have synaesthesia, he responded "unsure" to several forms of synaesthesia on his online questionnaire. While discussing these possibilities with Lucas during the interview however, the perceptions that he described in this context were deemed to be typical multisensory associations, and not synaesthesia.

The interview conducted with Lucas was undertaken over two sittings, due to a prior commitment of Lucas's mid-way through the interview. This interview was also the longest conducted as part of this study, at over two hours in length. Lucas demonstrated a keen interest in the study, and was not only candid in his answers, but also demonstrated a sharp curiosity for both AP and synaesthesia research in general. He was open to discussing aspects of his unique perception of music that he had, by his own admission, never discussed with anyone else before.

26. Liam

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
	✓	Violin	Violin	4	25	M

As a first year Master of Music (Performance) student, Liam's principle instrument is the violin, for which he began formal training at the age of 4. Liam reports that his mother, maternal grandmother, and younger brother all have AP. Liam is the second of three boys, and also believes that there is a strong possibility that his older brother has AP and synaesthesia. These potential conditions are not clearly detectable, as his older brother has been diagnosed with severe autism and epilepsy. He has, however, demonstrated intense listening skills and exhibits a highly particular sense of what he wants from sound.

Liam has AP. He describes the "slow realisation" during his school years that his AP was a special ability as one that both he and his younger brother enjoyed, using it to show off and boast to fellow musicians. This awareness made him, in his own words, quite "cocky and arrogant".

As a child, Liam's mother would supervise his daily practice from his initial lessons at the age of 4 until his early teens. This directed practice regime included instantaneous feedback and correction from his mother at the piano and was seen by Liam as both beneficial and detrimental, due to the fact that at the cessation of this supervision he felt "helpless" and had difficulty structuring his own practice. Nonetheless, Liam does not believe that he had to learn AP, but rather that it was something that he "never, ever" had to think about. Liam has, however, recently observed that the speed with which he is able to label pitches in the extremes of

registers has decelerated since his adolescence. He now feels that the process is less instantaneous in this particular case than it was when he was younger. He had also mentioned previously that his mother's AP is not as strong as it used to be and indicates her age as the key factor in this deterioration.

The interview was scattered with prolonged pauses: an indication of the level of reflection Liam applied when responding. At the completion of the interview, Liam produced an iPad on which he had listed points concerning his AP that he felt were pertinent to the study. He consulted this list but felt that all of his listed topics had been covered. The meticulous nature with which Liam approached the interview questions was thus supplemented by his prior reflection on both the upcoming interview and his AP ability in general.

27. Zoe

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
	✓	Piano	Piano	6	20	F

As a second year Bachelor of Music (Performance) student, Zoe's principle instrument is the piano, for which she began formal training at the age of 6. Zoe was born in China, and her mother tongue is Mandarin. She moved to Australia at the age of 6, and thus speaks English fluently. Zoe has a four-year-old brother whom she describes as having a very good ear, and while he is yet to begin formal musical training, she is interested in seeing whether he will display an AP ability like hers in the future. Both of Zoe's parents are piano teachers, and both also sing and teach singing as well. Her maternal grandfather is a senior choir conductor in China, who

moreover often travels to Australia to conduct senior choirs here. To her knowledge, however, none of her relatives have AP.

Zoe has AP. While defining her ability as automatic, she describes in detail the mental image of a piano keyboard that accompanies every externally or internally heard pitch. On rare occasions she may also visualise individual notes on a stave, but this imagery is not as strong for her. One further multisensory representation of her AP involves her depiction of musical keys that contain sharps as being "warmer", while keys that contain flats are conversely "colder". Zoe attributes the rapidity and facility of her musical memory to her AP.

During the interview Zoe mentioned her "pride" in having AP and outlined her belief that the ability was central to the development of her high level of musical talent. While she sees herself as both visually and musically artistic, her AP ability acted as a key motivator in her desire to continue musical studies. Zoe is particularly draw to composition and professed that the mnemonic benefit imparted by her AP is one of the greatest benefits of the ability: an ability she believes she was born with.

28. Lachlan

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
	✓	Bassoon	Bassoon	13	19	M

As a first year Bachelor of Music (Performance) student, Lachlan's principle instrument is the bassoon, for which he began formal training at the age of 13. Prior to this Lachlan had also participated in school-run keyboard lessons from approximately

the age of 9 onwards, however he does not believe that this instruction was taught in a serious manner.

Lachlan qualified as having AP, performing just above the AP cut off rate for piano tones, for which his performance was stronger than for pure tones. Interestingly, he did not make any semitone errors for the piano tones task, and very few for the pure tones task. His score was therefore assembled from a combination of both blank responses, and substantial labelling errors. He admits that certain factors do influence his pitch-naming ability, including register, the position of the note within a group of notes, the speed with which they are played, and how much practice he has been doing.

Although Lachlan did not begin serious formal musical training until early adolescence, he does have childhood recollections of his father singing constantly: an activity for which he and his siblings would partake. It is notable that from a very young age he would compare his pitch centring abilities with those of his two older siblings and did recognise he would start familiar songs on the correct starting pitch, while they would not. This propensity to not only start at the correct pitch, but also to identify that his siblings were not, are abilities he has had for as long as he can remember.

29. Alexander

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
	✓	Piano	Piano	5	19	M

As a second year Bachelor of Music (Performance) student, Alexander's principle instrument is the piano, for which he began formal training at the age of 5. Initially taught using the Yamaha method, he began learning both classical and jazz piano with two different teachers from the age of 7. He also plays the violin. Alexander was born in Indonesia, and his mother tongue is Indonesian. He moved to Australia at the age of 12, and now speaks English fluently. Alexander has two younger brothers, the youngest of whom also has AP. His father is an amateur autodidact pianist, while his mother enjoys music; Alexander believes both his parents and his other brother have "good ears", but not AP.

Alexander has AP. A substantial focus of the interview centred on the positive impact AP has on Alexander's self-esteem and motivation. He recounted several stories of musical "challenges" he has been given by both music professionals and friends from the age of 10 onwards, showcasing feats of musical memory or AP. He displays a predilection for playing back previously unheard songs, and this has been the focus of several confidence-boosting events during his High School years. By his own admission his AP has engendered feelings of being special, unique, and gifted, and even fuelled debate of the potentiality of him being a music savant.

Alexander believes he has excellent short- and long-term musical memory, and attributes this to his AP. This in turn enables him to smoothly overcome memory lapses, thus increasing his confidence when performing. He qualifies his musical

imagery as equally exceptional, and describes this internal soundtrack as occurring constantly. Although central to his musical identity, and viewed extremely positively by Alexander, AP affects him adversely in certain situations. Music played at pitches other than A=440 generates negative physical effects, including headaches and an overwhelming desire to leave the physical environment he finds himself in.

At the completion of the interview Alexander mentioned how grateful he was for the opportunity to discuss particular subjects that he admitted to never having previously mentioned to anyone before. He also conceded that many of the questions asked were novel and had kindled in him a deeper degree of thinking about AP and his musical abilities in general. This newfound depth of though is something he intends to continue to develop.

30. Max

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
	✓	Piano	Piano	3	40	M

As a member of the Conservatorium of Music's professional staff (Lecturer), Max's principle discipline is piano performance. Max began formal musical training on the piano at the age of 3, while he also played violin for a substantial part of his childhood. Max was born in Australia of Chinese origin but does not speak a language other than English. He has one younger brother who is on the autism spectrum, is epileptic, and who also has AP.

Max has AP. Although he does not have synaesthesia, there were several types listed on the online survey for which he selected 'unsure'. In discussing these with Max it

was decided that while not classifiable as synesthetic, he does associate distinct emotions with specific keys, and this is intrinsically linked to his AP. Max reports experiencing highly vivid musical imagery, which in certain conditions can block out external sounds. This strong imagery is intimately linked to his musical memory, which he asserts is equally robust. While Max believes he was born with AP, he presumes it may be possible to teach the ability during a certain age window, with appropriate training. Max completed a degree in Law and Commerce before deciding to pursue a career in piano performance, thus undertaking studies at the Conservatorium from the age of 22. This decision hinged on Max's desire to produce music that gives him great enjoyment and emotional fulfilment.

At the completion of the interview Max declared that his participation in this study had obliged him to reflect on aspects of his pitch perception that had previously remained untouched by him, thus expanding his understanding of his unique perceptual abilities. He furthermore acknowledged that his AP ability is becoming more malleable with age. As his AP is an integral part of his musical identity and he admits to being heavily reliant on it, this potentiality frightens him.

31. Cooper

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
	✓	Composition	Piano	6	19	M

While Cooper is a second year Bachelor of Music (Composition) student, his principle instrument is the piano, for which he began formal training at the age of 6. He also plays the pipe organ and the double bass.

Cooper has AP. As a child, he was exposed to two different teaching methods: his piano lessons involved Yamaha training, while he was exposed to the Kodály method when singing with the Australian Boys Choir. His earliest memory of his AP stems back to when he initially began formal piano lessons at the age of 6, however he was only formally made aware of his AP ability at around the age of 10 through his involvement with the Australian Boys Choir. Moreover, while discussing his early musical training, Cooper refers to an aural test he was given as a 4-year-old, after which his parents were told he had AP. It is important to note this aural test was given to Cooper before the onset of his musical training, and while he does not know why he was tested, he has been told of this test and its diagnosis. Cooper's personal belief is that there is a genetic or innate component to his AP ability, which has been developed through his extensive early musical training. Cooper decided to become a composer during his late primary school years but has records of early compositions he wrote from the age of 7. He believes his AP ability was one of the factors that motivated this decision.

During the interview Cooper made several references to the fact that he struggles with memory and recall. He feels this particularly with musical memorization, but this is a general difficulty he faces, and one that impacts his compositional and performance tasks. He similarly describes his belief that his aural, and in particular his visual, imagery is lacking in vividness. The origin of this difficulty is unclear. Conversely to what has been expressed by other participants, Cooper is not perturbed by the potential loss or diminution of his AP ability due to age or other factors. Indeed, he states he would find it "interesting" if that were to occur, and although he would not

want to entirely lose his AP ability, he did mention he would like to experience not having AP for a short length of time.

32. Henry

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
	✓	Composition	Piano	6	23	M

Henry is a composition student, while also in his third year of a Bachelor of Commerce majoring in Accounting and Finance. His principle instrument is the piano, for which he began formal training at the age of 6, while he also plays the guitar. Henry is a native Cantonese and Mandarin speaker, and only began learning English at school.

Henry has AP. He describes his AP as automatic, yet also indicates he frequently pictures a piano keyboard in his mind's eye when he hears individual tones, or a single line melody. This image includes a hand, pressing down the keys that correspond to the heard tone/s. Also of particular interest is Henry's admission that while he perceives individual pitches with accuracy, he cannot produce pitches in the same way. Thus, when asked to sing a particular note, he will often be incorrect in his delivery. Analogously, he notes his aural imagery, while being highly vivid, is also prone to being in the wrong key.

While he does not have synaesthesia, Henry mentioned during the interview that he did perceive a difference in tonal quality produced by sharp major keys and flat major keys. For him, sharp keys are more aggressive, while flat keys are mellower. He

describes this bias as “stupid” but is unable to modify his perception. Overall, Henry remains largely impervious to his AP, even though he is ultimately happy to have it.

33. Sienna

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
	✓	Oboe	Piano	5	20	F

As a third year Bachelor of Music (Performance) student, Sienna’s principle instrument is the oboe. She began her formal musical education at the age of 5 on the piano, before commencing the oboe at age 10. She also plays the cor anglais. Sienna is the last of four sisters. While the eldest does not have AP, the other three sisters do, with both Sienna and one of her sisters with AP both studying music at a tertiary level. Though neither of her parents are musicians, her maternal grandmother was an organist.

Sienna has AP. She believes she had AP even before beginning her musical training, although whether this was due to constant exposure to her sisters’ piano CDs or whether this was an innate ability, remains unsure. Regardless of its origin, what is noteworthy is that she has always known about her and her sisters’ AP and does not remember a time when this knowledge was absent. She decided to pursue a career in music in late primary school, and attributes this decision in part to the ease and comfort that her AP provides her.

Sienna notes that while her AP confers notable benefits, she is also wary of the negative effects that it brings. In particular, she acknowledges that she needs to remain vigilant about her habit of learning music by listening to recordings, rather

than score reading. She is aware that during her own interpretation of a piece, her reliance on aural memorisation has led to her tendency to mimic what she had heard when listening to recordings. Thus, while her AP does positively influence her musical memorisation skills, it can also inhibit her interpretative decision-making. Ultimately, however, she admits she cannot imagine her world without AP, as it is an integral part of her musical identity.

34. Oliver

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
	QAP	Aural Studies	Piano	11	53	M

As a member of the Conservatorium of Music's professional staff (Lecturer), Oliver's principle disciplines are aural studies and musicology. While he has been involved in musical activities since commencing primary school, he only started formal lessons on the piano at the age of 11. Learning the organ however, had been his principle objective ever since he experienced a *coup de coeur* for the instrument at the age of 7. Eventually, at the age of 16, he began formal training on the organ. Oliver also plays the harpsichord, sings, and is heavily involved with music theatre and cabaret. Oliver has been auto-diagnosed with 'high-functioning autism', after suspicions drew him to complete an online test battery. He feels the diagnosis explains what he has always intrinsically known.

Oliver used to have robust AP, but now qualifies as a QAP possessor. He has ascertained that two factors have impacted his AP ability in a discernible way: the natural effects of ageing, and a major road accident he was involved in nearly a decade ago, which left him with serious injuries, including traumatic brain injury.

These given reasons may explain why Oliver did not score within the AP range, but did qualify as having QAP. While he does not have synaesthesia now as an adult, the questionnaire he was given to complete prior to the interview made him reflect on his childhood. He distinctly remembers instances where voices, which were then linked to the physical appearance of the person in question, had both corresponding colours and flavours. He dimly remembers experiencing changes in colour percepts in relation to changes in musical keys while playing, but all of these synesthetic experiences ended during preadolescence.

From the outset, Oliver has been a strong supporter of this study, giving of his time freely to discuss theoretical and methodological considerations. His candid willingness to discuss the challenges he has faced in the last few years, and the impact these have had on his personal and professional life was evident throughout the study. During the interview process he took great care in answering the questions posed to him with intellectual rigour, taking the time to dissect his experiences with meticulous attention to detail.

35. Amelia

SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
	QAP	Music Therapy	Piano	4	22	F

While Amelia is a first year Master of Music (Music Therapy) student, her principle instrument is the piano, for which she began formal training at the age of 4. As an adolescent she also began guitar lessons, and this is the instrument that she now plays most frequently. Amelia is from Hong Kong, and her mother tongue is Cantonese, while she also learnt Mandarin and English at school. She moved to Australia when

she was 17, and has a younger sister who has AP, but is not involved with music on a professional basis.

Amelia did not qualify as having AP, but did perform above chance, and has qualified as having QAP. Even when semitone errors were counted, she still fell within the QAP range. It should also be noted that during the interview she sung what she described as being a “C”, however on verification what she actually sung was an “A”, thus demonstrating the inconsistent nature of her ability.

Amelia describes how she has developed her QAP ability through training, by playing certain notes persistently, and depicts her amazement at being able to name particular notes after this training. It remains unclear, however, to what extent her QAP has improved through this training, as she does herself believe that not everyone can develop the ability, regardless of their level of training. Amelia furthermore explains that she desires to improve her faculty through additional training and is particularly keen on gaining the ability to labelling chords and multiple pitches at one time.

A.4. A Tabulated Overview of the Demographic Details of all 35 Participants.

The table includes the name, condition(s), principle instrument, initial instrument, age of commencement of formal musical training, age at time of interview, and gender, of each participant. The table follows the same participant order as the above synopses.

Name	SYN	AP	Principle Instrument	Initial Instrument	Age started	Age now	Gender
James	✓	✓	Voice (Baritone)	Piano	7	18	M
Mason	✓	✓	Violin	Piano	6	20	M
Ella	✓	✓	Composition	Piano	4	24	F
Xavier	✓	✓	Violin	Piano	5	22	M
Samuel	✓	✓	French horn	French horn	7	18	M
Benjamin	✓	✓	Musicology	Piano	3	23	M
Matilda	✓	✓	Saxophone	Piano	5	18	F
Olivia	✓	QAP	Composition	Piano	10	48	F
Mia	✓	QAP	Voice (Soprano)	Violin	7	19	F
Chloe	✓	QAP	Composition	Piano	6	54	F
Grace	✓	QAP	Piano	Accordion	4	27	F
Charlotte	✓		Flute	Flute	7	23	F
Jack	✓		Composition	Percussion	12	27	M
Ethan	✓		Piano	Piano	4	21	M
Thomas	✓		Oboe	Oboe	13	19	M
Isabella	✓		Composition	Piano	5	20	F
Ruby	✓		Voice (Soprano)	Voice	5	22	F
Lily	✓		Voice (Soprano)	Cello	5	31	F
William		✓	Piano	Piano	7	20	M
Noah		✓	Electric Bass	Electric Bass	10	18	M
Ava		✓	Cello	Piano	2	20	F
Emily		✓	Piano	Piano	5	20	F
Sophie		✓	Musicology	Piano	5	30	F
Joshua		✓	Composition	Piano	7	45	M
Lucas		✓	Voice (Tenor)	Voice	17	19	M
Liam		✓	Violin	Violin	4	25	M
Zoe		✓	Piano	Piano	6	20	F
Lachlan		✓	Bassoon	Bassoon	13	19	M
Alexander		✓	Piano	Piano	5	19	M
Max		✓	Piano	Piano	3	40	M
Cooper		✓	Composition	Piano	6	19	M
Henry		✓	Composition	Piano	6	23	M
Sienna		✓	Oboe	Piano	5	20	F
Oliver		QAP	Aural Studies	Piano	11	53	M
Amelia		QAP	Music Therapy	Piano	4	22	F

Appendix B.

Email sent to all participants, inviting them to complete the online questionnaire.

> Good evening. Thank you for agreeing to be part of this fascinating study on Synaesthesia and Absolute Pitch! As we discussed, there are three components to the research, the first of which is an online questionnaire that is expected to take 15 minutes to complete. Here is the link:
>
> http://sglasser13.polldaddy.com/s/synaesthesia-absolute-pitch-study
>
> All you have to do is click on the link and fill it out: once it's completed, I will get the results sent to me. Please be as honest as possible. Remember: I will be using a pseudonym at all times! Once you have finished it, we can work out a time to meet up for an interview, at a time and place that would be most convenient for you in the next few weeks. If you have any questions, please don't hesitate to send me an email, and I will get back to you as soon as possible.
>
> Thank you once again, and I hope you have fun!
>
> Solange

Appendix C.

Opening page of the online Questionnaire.

Welcome to the first phase of research into the impact of Synaesthesia and Absolute Pitch (AP) on specific musical capacities. This research is being conducted by Prof Gary McPherson and Mrs Solange Glasser of the Faculty of the MCM at The University of Melbourne.

We greatly appreciate your interest in our study and thank you for agreeing to participate. This questionnaire will take an estimated 15-20 minutes to complete.

This project has been approved by the Human Research Ethics Committee at the University of Melbourne (ID number: 1340162). We treat all information as strictly confidential, and only members of the research team will be able to access your personal information. Your data may be used in public presentations and academic papers, including the Student Researcher's dissertation, however at no stage will any personally identifying information and data be made available, and pseudonyms will be used at all times. All data will be held for a minimum of 5 years after the publication of the Student Researchers' PhD thesis, in accordance with the University of Melbourne's Code of conduct for Research. The data may be kept indefinitely on the Student Researchers' password protected computer, and subsequently used in future publications, including journal articles and conference proceedings.

If you have any questions before you begin, please do not hesitate to contact the Student Researcher, Solange Glasser: s.glasser@student.unimelb.edu.au

Appendix D.

Full list of questions asked in the online questionnaire.

Demographic Information

In this first section, you are asked about personal factors that are relevant to our research.

Name:

Date of Birth:

Date today:

Gender: Male/Female

What course are you currently enrolled in? (BMus/BMusHons/ DipMus/Masters/PhD/Staff)

What year of your course are you in? 1-3/ N.A

What is your specialisation? (Performance, Composition, Conducting, …Education)

Is English your mother tongue?

Do you speak fluently any languages other than English?

> If yes, which ones?
>
> If yes, which of these languages (including English) did you learn fluently before beginning school?

Are you left or right handed? Left/Right

Musical Background

Please answer the following questions about your musical background.

At what age did you begin formal musical training?

What is your primary instrument (including voice)?

How many musical instruments (excluding voice) do you play?

> What are these?

How many days a week do you practice?

In a typical week, what days of the week would you normally practice?
Monday Tuesday Wednesday Thursday Friday Saturday Sunday

On these days, how much practice time in minutes would you average?

What is the highest AMEB/Trinity grade that you have completed (1-8, Associate, Licentiate)

What result did you get?

Absolute Pitch and Synaesthesia

In the following section, we will ask you some questions about Absolute Pitch and Synaesthesia.

Absolute Pitch

Absolute pitch is the ability to recognize and name a musical pitch without the assistance of a reference tone. It is sometimes referred to as perfect pitch.

Do you have absolute pitch? (Yes – Completely confident; Not sure; No)

Do any members of your family have absolute pitch? (Yes; Not sure; No)

If so, who?

If you answered brother or sister in the previous question, are you a twin, triplet, etc.?

If so, identical or fraternal?

Synaesthesia

Synaesthesia is a neurological condition in which stimulation of one sensory or cognitive pathway leads to automatic, involuntary experiences in a second sensory or cognitive pathway. People who report such experiences are known as synesthetes. For example, a synesthete may perceive numbers and letters as coloured, or musical pitches as having distinct flavours.

Do you have synaesthesia? (Yes – Completely confident; Not sure; No)

Do any members of your family have synaesthesia? (Yes; Not sure; No)

If so, who?

If you answered brother or sister in the previous question, are you a twin,

triplet, etc.?

If so, identical or fraternal?

Here is a list of the currently known types of synaesthesia in alphabetical order. This list has over 60 types of recognized synaesthesia, but is constantly being updated as more types are being discovered. If you feel that you may have a type of synaesthesia not listed below, please write it down in the space provided, and we will discuss it during your interview. It is common for synesthetes to have several types of synaesthesia, so there is no limit to the number of positive responses you may give.

In the following list, the first word is the trigger, and the second word after the arrow is the synesthetic percept that is experienced in response to the trigger.

For example:

- If you perceive numbers and letters as coloured, then you have grapheme→colour synaesthesia.
- If you see colours when listening to music, then you have musical sound→colour synaesthesia.
- If you see the days of the week, months of the year, or years mapped-out in the space in front of, or surrounding your body, then you have spatial sequence synaesthesia.

Please place a tick in the YES box next to the types of synaesthesia you know you have, and if you are unsure, place a tick in the UNSURE box. If you are sure that you don't have a particular type, then please leave it blank.

For each item on the following list, indicate whether you are sure (Yes), or unsure that you have this form of synaesthesia:

YES UNSURE

Emotion→colour
Emotion→flavour
Emotion→odour
Emotion→sound
Flavour→colour
Flavour→sound
Flavour→temperature
Flavour→touch
General sounds→colour
Grapheme→colour
(i.e. number/letter→colour)
Grapheme personification (Ordinal Linguistic Personification)
(i.e. Numbers/Letters→personalities)
Grapheme→touch
Kinetics→colour

(i.e. Motion or movement→colour)
Kinetics→personality
Kinetics→sound
Lexeme→flavour
(i.e. heard or read words→flavours)
Lexeme→odour
Lexeme→touch
Mirror touch
(i.e. physically feeling when seeing someone else being touched)
Musical instrument sound→colour
Musical instrument sound→flavour
Musical key/tonality/mode→colour
Musical key/tonality/mode→flavour
Musical notation read on the score→colour
Musical note→colour
Musical note→flavour
Musical sound→colour
Musical sound→spatial coordinate
Non-graphemic ordinal personification
(i.e. Days/Months etc.→personalities)
Object personification
Orgasm→colour
Orgasm→flavour
Pain→colour
Personality→colour ("auras")
Personality→flavour
Personality→smell
Personality→touch
Phoneme→colour
(i.e. unit of speech sound→colour)
Smell→colour
Smell→flavour
Smell→sound
Smell→temperature
Smell→touch
Sound (non musical)→colour
Sound→flavour
Sound→kinetic
Sound→smell
Sound→temperature
Sound→touch
Spatial sequence or number form
(i.e. Seeing number sequences in physical space)
Swimming styles→colour
Temperature→colour
Temperature→sound
Ticker-tape
(i.e. Speech or thought subtitled)
Time units→colour
Time units→sound

Touch→colour
Touch→flavour
Touch→smell
Touch→sound
Touch→temperature
Vision→flavour
Vision→kinetic
Vision→smell
Vision→sound
Vision→temperature
Vision→touch

Other …….

To the best of your knowledge have you always had these sensations?

Medical History

In this final section, we would like to ask you some questions about your family medical history. Please remember that any information you provide will remain anonymous and strictly confidential.

Have you ever suffered from seizures?

Have you been diagnosed with epilepsy?

Have you or a member of your family been diagnosed with an autism spectrum disorder?

If so, who?

Have you or a member of your family received treatment for a neurological condition or disorder?

If so, who?

End of Questionnaire

Thank you very much for giving us your time to complete this questionnaire.

If you have any further questions or concerns regarding this Questionnaire, or would like to give us your feedback, please email Solange Glasser at:
s.glasser@student.unimelb.edu.au

Appendix E.

Synaesthesia and absolute pitch study interview.

This interview guide was developed based on a semi-structured worldview interview model, and includes an outline of the topics covered, with suggested questions. Participants were only questioned on their self-reported aptitudes (whether they have Synaesthesia, Absolute Pitch, or both), based on information they provided in the Questionnaire, which preceded this interview. The relevance and importance of many of the questions outlined below were dependent on the individual answers given in the Questionnaire, and follow up questions were asked where appropriate.

Outline of Topics

1. Briefing
2. Synaesthesia
    A. Childhood and Family
    B. General Health and Wellbeing
    C. Drug Consumption and Medication
    D. Creativity and Musicianship
        a. Types of Synaesthesia
        b. Musical Abilities
        c. Performance
        d. Motivation
3. Absolute Pitch
    A. Childhood and Family
    B. Health and Wellbeing
    C. Creativity and Musicianship
        a. Types of Absolute Pitch
        b. Musical Abilities
        c. Performance
        d. Motivation
4. Both Synaesthesia and Absolute Pitch
5. Debriefing

BRIEFING

Thank you for your willingness to participate and be interviewed here today. I have been studying the effects of Synaesthesia and Absolute Pitch on different musical skills, and am now interested in learning about how having (Synaesthesia) (and) (Absolute Pitch) influences you as a musician. Let me first begin by saying that if at any time during this interview you wish to take a break, just let me know and we can do that. If you feel uncomfortable answering any question then please say "pass" and I will move on to the next question.

It is always possible that some time after the interview has finished you may experience emotions that you would like to talk about, and I would strongly encourage you to contact the University's Counselling and Psychological Services. You can find their contact details on the Plain Language Statement that you were given when you agreed to participate in this study. Do you have any questions before we get started?

SYNAESTHESIA

Synaesthesia is a neurological condition in which stimulation of one sense leads to experiences in a second sense or modality. For example, colours may be experienced in response to music or words, or shapes may be experienced in response to tastes. These extra synesthetic experiences are called percepts.

Childhood and Family

Try to remember as far back as you can. What is your very earliest memory of a synesthetic experience?

1. About how old were you?
2. Where were you?
3. What were you doing?
4. What happened?
5. How did you feel?
6. How did it affect you at the time and just after?
7. Was anyone else around?
8. Did you tell anyone else (e.g. parents)?

When were you made aware that what you were experiencing was actually Synaesthesia? Was it something that very early in your life, you were made aware of as a form of personal experience?

Try to remember the most powerful synesthetic experience you have ever had. Can you tell me about it?

1. About how old were you?
2. Where were you?
3. What were you doing?
4. What happened?
5. How did you feel?
6. How did it affect you at the time and just after?
7. Was anyone else around?
8. Did you tell anyone else (e.g. parents)?

Try to remember a very recent experience.

1. When was it?
2. Where were you?
3. What were you doing?
4. What happened?
5. How did you feel?
6. How did it affect you at the time and just after?
7. Was anyone else around?

8. Did you tell anyone else (e.g. parents)?

What can you tell me about these conversations? What was said to you? How did you feel? Was there any follow up (for example, a parent doing or saying something at a later time?)

Do any of your other family members or friends have Synaesthesia? If so, who? When did you find out? How did you find out? What type of conversations did you have with this person (or these people)? Are they themselves musicians, either amateur or professional, or do they have other artistic professions?

I'd like to introduce a new topic.

Idiopathic or real Synaesthesia comes in two forms: Innate, meaning you were born with it, or Induced, meaning that it was acquired later on, by one of several means. To understand into which of these categories your perceptions belong, I would like to ask you with your permission a few questions regarding your health, wellbeing, and past drug consumption.

Health and Wellbeing

If participants answered YES to either of the Questionnaire Questions: Have you ever suffered from seizures? or *Have you been diagnosed with epilepsy?:*

> Were you aware of your Synaesthesia before this diagnosis, or before the onset of your seizures?

Do you suffer or have you suffered from any condition that you believe may have affected your synesthetic percepts?

Have you ever been in a situation of extreme hardship, such as extreme hunger or cold? Were you aware of your synesthetic percepts before this event? Did this experience affect your synesthetic percepts?

Do any other factors affect your synesthetic percepts? (If no: alcohol, coffee, or energy drinks? General mood, fatigue, or stress? In what way?)

Are the percepts automatic and involuntary, or can you start and stop them as you please?

Where do you experience your synesthetic percepts? (If unsure, exterior to your body (in the space surrounding your body), or interiorly: "in the mind's eye"?)

Do the same inducing factors always lead to the same percepts, or do they change (for example, if the letter A is red, then it is always red, or it is a different colour on a different day)?

Are the percepts memorable? Do you easily remember them?

Do they affect how you remember things?

To what degree are your synesthetic percepts emotional?

Have there been occasions where you have felt a feeling of ecstasy because of your percepts, or on the contrary, have you ever had bad physical or emotional reaction when your percepts did not match the given stimulus, for example, if the colour of the lights didn't match the music?

Have you met other synesthetes? Did they have the same type(s) of Synaesthesia as you? Did you discuss the differences between your perceptions? What was your reaction to those differences?

Have you ever felt that you had a 'sixth-sense', or a higher than normal level of intuition? Any clairvoyant-type experiences?

How vivid are your percepts? How willingly do you give in to them – do they steer you, take control of you, or direct you in any way?

Drug Consumption and Medication

Have you ever consumed a hallucinogenic drug, such as LSD?

If yes, were you aware of your Synaesthesia before this consumption?

If yes, what was, if any, the effect of this consumption on your Synaesthesia?

Are you currently, or have you ever taken medication that has affected your Synaesthesia, and if so, in what way?

I would now like to introduce another topic:

Creativity and Musicianship

Here, participants will be asked to describe all their types of Synaesthesia. Exact questions will depend on type(s) described.

Types of Synaesthesia *(Only for participants who have sound-colour Synaesthesia [Chromesthesia] or other sound induced types of Synaesthesia)*

Could you describe in as much detail as possible what happens when you hear a specific pitch? (Thinking/feeling…?)

Does the instrument heard affect your Synaesthesia?

Do you only have Synaesthesia for some instruments?

Is your Synaesthesia affected by harmony or context?

Do you have an idea of how many notes at one time you could process the colours for?

As far as you know, can you tell by how far a note is out of tune? (If yes, is this by it's colour or not?)

Are you able to identify the colour of non-musical sounds?

Musical abilities

In your opinion, how does having Synaesthesia impact on your musical abilities? Which abilities?

Are certain musical tasks made easier by your Synaesthesia? Harder?

Is your Relative Pitch affected by your Synaesthesia?

Does, or would your Synaesthesia affect your ability to play a transposing instrument?

Does transposing affect your synesthetic percepts?

How does Synaesthesia affect your creativity? In general, and in music in particular?

Has your Synaesthesia affected your choice of instrument?

Has your Synaesthesia affected your choice of music that you listen to, or repertoire?

Has your Synaesthesia affected your preferences relating to musical style? …your aesthetic experience of music?

Has your Synaesthesia affected your personal or professional relationships, including your choice of, or relationship with, your teacher?

Performance

Does your Synaesthesia play a part in your musical interpretation? Does it lead to any intense feelings? If so, describe.

Does Synaesthesia affect your confidence in performance?

Do any feelings of anxiety and stress related to performing affect your Synaesthesia? If so, describe how and in what ways they do.

Motivation

As far as you can remember, to what degree did having Synaesthesia motivate you to start musical training when you were younger?

To what degree has having Synaesthesia motivated you to study music at a tertiary level?

Imagine – if you can - that you didn't have Synaesthesia. What might you have done differently?

What's the best thing about having Synaesthesia?

What's the worst thing about having Synaesthesia?

If you had a choice to have or not have Synaesthesia, what would you choose? Why?

ABSOLUTE PITCH

Childhood and Family

Try to remember as far back as you can. What is your very earliest memory of your Absolute Pitch?

1. About how old were you?
2. Where were you?
3. What were you doing?
4. What happened?
5. How did you feel?
6. How did it affect you at the time and just after?
7. Was anyone else around?
8. Did you tell anyone else (e.g. parents)?

When were you made aware that what you were experiencing was actually AP? Was it something that very early in your life, you were made aware of as a form of personal experience?

Try to remember the most powerful experience involving AP you have ever had. Can you tell me about it?

1. About how old were you?
2. Where were you?
3. What were you doing?
4. What happened?
5. How did you feel?
6. How did it affect you at the time and just after?
7. Was anyone else around?
8. Did you tell anyone else (e.g. parents)?

Try to remember a very recent experience.

1. When was it?
2. Where were you?
3. What were you doing?
4. What happened?
5. How did you feel?
6. How did it affect you at the time and just after?
7. Was anyone else around?
8. Did you tell anyone else (e.g. parents)?

What can you tell me about these conversations? What was said to you? How did you

feel? Was there any follow up (for example, a parent doing or saying something at a later time?)

Do any of your other family members or friends have AP? If so, who? When did you find out? How did you find out? What type of conversations did you have with this person (or these people)? Are they themselves musicians, either amateur or professional, or do they have other artistic professions?

I'd like to introduce a new topic.

Health and Wellbeing

Do you or have you suffered from any condition that you believe may have affected your pitch perception?

Have you ever been in a situation of extreme hardship, such as extreme hunger or cold? Were you aware of your AP before this event? Did this experience affect your AP?

Do any other factors affect your AP? (If no: alcohol, coffee, or energy drinks? General mood, fatigue, or stress? In what way?)

Is your AP automatic and involuntary, or can you turn it off?

Where do you experience your AP? Do individual pitches have spatial locations? (If unsure, exterior to your body (in the space surrounding your body), or interiorly: "in the mind's eye"?)

Does AP affect how you remember things?

To what degree is your AP emotional?

Have there been occasions where you have felt a feeling of ecstasy because of your AP, or on the contrary, have you ever had bad physical or emotional reaction because of your AP?

Have you met other people with AP? Did you discuss your AP with them?

Have you ever felt that you had a 'sixth-sense', or a higher than normal level of intuition? Any clairvoyant-type experiences?

Drug Consumption and Medication

Have you ever consumed a hallucinogenic drug, such as LSD?

If yes, were you aware of your AP before this consumption?

If yes, what was, if any, the effect of this consumption on your AP?

Are you currently, or have you ever taken medication that has affected your AP, and if so, in what way?

I would now like to introduce another topic:

Creativity and Musicianship

Here, participants will be asked to describe their AP. Exact questions will depend on type(s) described.

Type of Absolute Pitch

Absolute Pitch, commonly referred to as Perfect Pitch comes in two forms: Absolute Pitch, and Quasi Absolute Pitch. To understand into which of these categories your AP belongs, I will ask you a few questions regarding your musical abilities.

Could you describe in as much detail as possible what happens when you hear a specific pitch? (Thinking/feeling…?)

Does the instrument heard affect your AP?

Do you only have AP for some instruments?

Is your AP affected by harmony or context?

Do you have an idea of how many notes at one time you could process?

As far as you know, can you tell by how far a note is out of tune?

Are you able to identify the pitch of non-musical sounds?

Musical abilities

In your opinion, how does having AP impact on your musical abilities? Which abilities?

Are certain musical tasks made easier by your AP? Harder?

Is your Relative Pitch affected by your Absolute Pitch?

Does, or would your AP affect your ability to play a transposing instrument?

Does transposing affect your AP?

How does AP affect your creativity? In general, and in music in particular?

Has your AP affected your choice of instrument?

Has your AP affected your choice of music that you listen to, or repertoire?

Has your AP affected your preferences relating to musical style?

Has your AP affected your personal or professional relationships, including your choice of, or relationship with, your teacher?

Performance

Does your AP play a part in your musical interpretation? Does it lead to any intense feelings? If so, describe.

Does AP affect your confidence in performance?

Do any feelings of anxiety and stress related to performing affect your AP? If so, describe how and in what ways they affect your AP.

Motivation

As far as you can remember, to what degree did having AP motivate you to start musical training when you were younger?

To what degree has having AP motivated you to study music at a tertiary level?

Imagine – if you can - that you didn't have AP. What might you have done differently?

What's the best thing about having Synaesthesia?

What's the worst thing about having Synaesthesia?

If you had a choice to have or not have AP, what would you choose? Why?

BOTH SYNAESTHESIA AND ABSOLUTE PITCH

If you have both AP and Synaesthesia, which is the more dominant? In what way is it more dominant? How do they interact if at all?

Do you use your synesthetic precepts to aid you in AP tasks, or do you feel like your AP does not need the sensory assistance of Synaesthesia?

Imagine if possible if you could switch off your Synaesthesia momentarily, do you think that your AP would remain?

Vice-versa, do you think that it would be possible to switch off your AP, if you still had Synaesthesia?

Do you use both your Absolute Pitch and Synaesthesia together when learning music? In what ways to they help you process music? For example, do they impact on any of these abilities:
Memorising music
Expression and phrasing
Technical ability
Sight-reading
Any other abilities?

DEBRIEFING

Is there anything else that you would like to discuss that will help me understand more clearly how the possession of Synaesthesia/AP impacts on you or your musical abilities?

Do you have any final questions?

The Interview is now finished. Thank you very much for your participation. Don't forget that I would be happy to receive any feedback that you may have by email if you wish, and if you do feel the need to talk to someone about this experience, you can find the contact details of the Melbourne University Counselling service on the Plain Language Statement I gave you at the very beginning.

Solange Glasser

Appendix F.

Email sent to all auto-diagnosed synesthete participants, inviting them to complete the online synaesthesia test battery.Thank you very much for sharing your experiences with me today during the interview. As we discussed, here is the Synaesthesia test link.

There are two steps to take. First, you must register using your email address, password and name (please do enter your name so that I am aware of whose test results it is). It will look like this:

Registration Form

* Email Address:
* Create a Password:
* Repeat Password:
First Name:
Last Name:

* Indicates required fields

Then, once you have registered and signed in, it will guide you to a page asking if you want to "Share your results with a researcher". It will look like this:

Share your results with a researcher?

The Synesthesia Battery involves taking simple computerized tests and questionnaires. Your results will be anonymously added to a database that researchers can access to learn more about synesthesia. If you are in contact with a specific researcher who has asked you to take these tests, enter his or her name and email address here. Otherwise, please leave these fields blank and click next.

Researchers Email Address:
Researchers Name:

Here, please enter my email address: sglasser@student.unimelb.edu.au and my name: Solange Glasser. After this, the test will begin. It is expected to take less than 20 minutes to complete, and once completed, you and I will be sent the results automatically. Here is the link:

http://synesthete.org/login.php?action=register

If you have any questions or concerns, please do not hesitate to email me, and I will get back to you as soon as possible.

Thank you very much!
All the best,
Solange

Appendix G.

Absolute pitch test copy sheet. Participants were instructed to write the name of the note they were hearing in the blank squares provided. Only the first two tasks are diagnostic, while tasks 3-11 (with crossed out squares) provide supplementary information.

1. PIANO TONES

TASK 1

1	2	3	4	5	6	7	8	9	10	11	12

TASK 2

1	2	3	4	5	6	7	8	9	10	11	12

TASK 3

1	2	3	4	5	6	7	8	9	10	11	12

2. PURE TONES

TASK 1

1	2	3	4	5	6	7	8	9	10	11	12

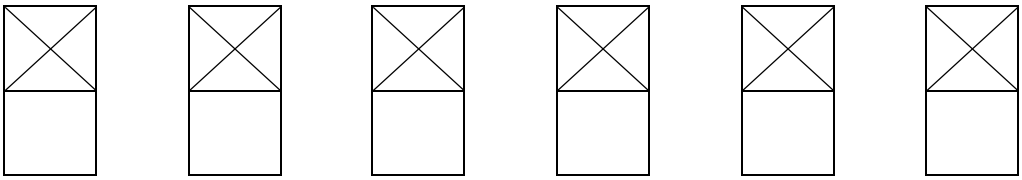
TASK 2

1	2	3	4	5	6	7	8	9	10	11	12

TASK 3

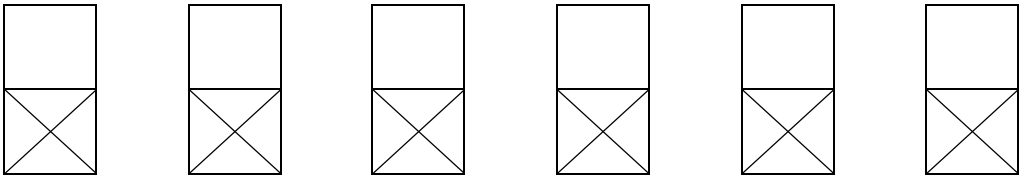
1	2	3	4	5	6	7	8	9	10	11	12

3. LABEL THE BASE (BOTTOM) NOTE



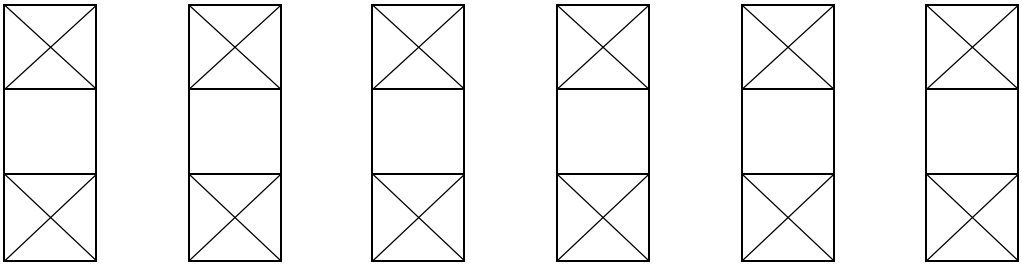
1 2 3 4 5 6

4. LABEL THE HIGHEST (TOP) NOTE



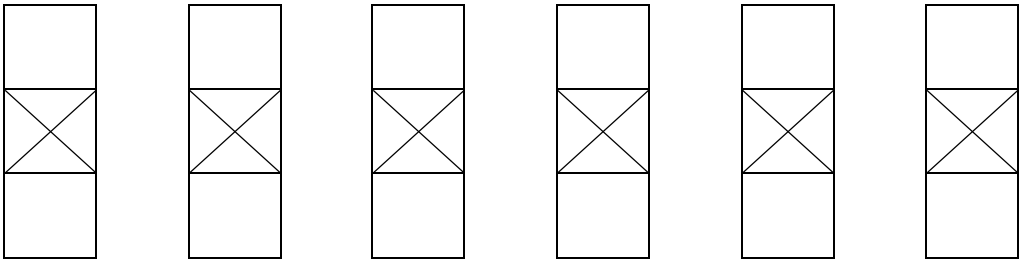
1 2 3 4 5 6

5. LABEL THE MIDDLE NOTE (OF THREE)



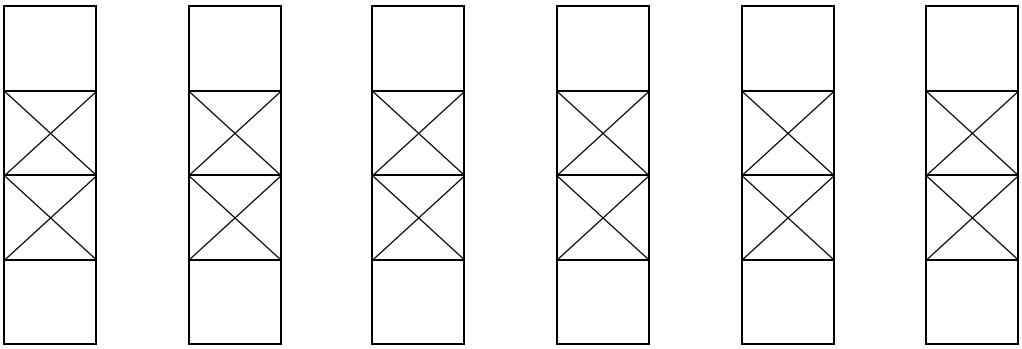
1 2 3 4 5 6

6. LABEL THE TWO OUTER NOTES (OF THREE)



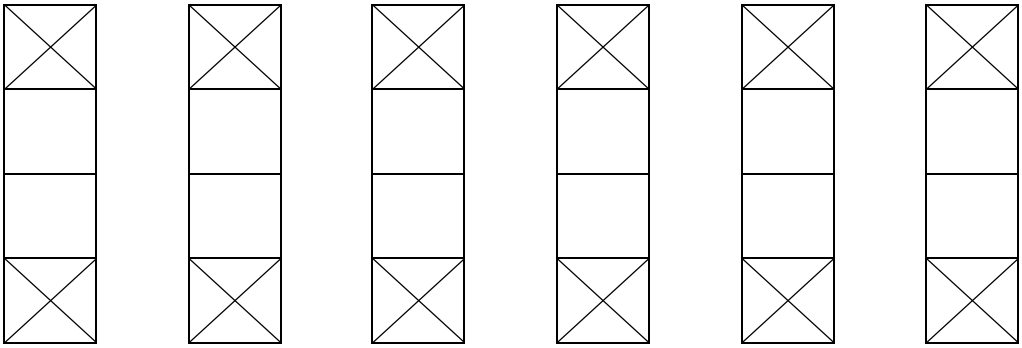
1 2 3 4 5 6

7. LABEL THE TWO OUTER NOTES (OF FOUR)



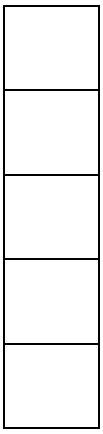
1 2 3 4 5 6

8. LABEL THE TWO INNER NOTES (OF FOUR)

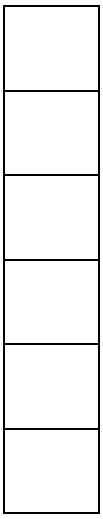


1 2 3 4 5 6

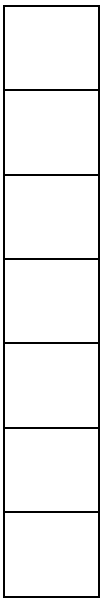
9. LABEL ALL FIVE NOTES



10. LABEL ALL SIX NOTES



11. LABEL ALL SEVEN NOTES



Appendix H.

List of 10 participants who indicated the vividness of their auditory imagery (AI) is ‘extreme’. This denotes that not only is their AI as strong as hearing a recording or live performance, but that it is able to ‘block out’ external sounds. A list of representative comments from each of these 10 participants is provided, as well as the condition(s) they possess. Note that ‘synaesthesia’ has been abbreviated to ‘syn’.

Name	Condition(s)	Comments
Benjamin	Syn/AP	There are times where I have been thinking of music and I've been so lost in the sound world that it blocks out external noises. Coming back to what I was saying about me going [laughs] around the playground, I think I could do that; I think I could block out the sounds of the children [pauses] with the music.
Mason	Syn/AP	I'm fairly good at blocking out the other sounds so that that's all I'm really hearing with my internal ear.
Chloe	Syn/QAP	Probably clearer because I'd be a little bit distracted on the radio by the way someone's interpreting it. But the music itself has a kind of "ooah" essence. I think it's clearer in my mind.
Olivia	Syn/QAP	I mean, you can hear orchestral instrument sounds in your mind, can't you? You hear the tones when they’re not being played. You hear how they should sound. That's a normal thing, is it not?
Jack	Syn	It can definitely take my attention away from other external things that may be happening.
Ethan	Syn	It's not really playing on a radio in the way that if something is playing on the radio, you can still hear other people. It's more that I can't hear anything but it.
William	AP	I'm able to block out what's going on around me and concentrate on what I'm hearing in my own mind as well.
Lucas	AP	I guess that's maybe one of the reasons why I can remember so much detail about something that I hear or a piece that I know well. I think that's what's enabled me to develop pitch memory.
Liam	AP	I can turn it up which is a nice thought to use to block things out.
Max	AP	If I'm thinking about how a phrase is going and somebody's talking to me, I might not hear them immediately.

Appendix I.

Paradigmatic quotes from participants who reported their condition(s) negatively impact their ability to play a transposing instrument. This table is non-exhaustive, but includes quotes that best exemplify the difficulties faced by participants. Note that 'synaesthesia' has been abbreviated to 'syn'.

Name	Condition(s)	Comments
Mason	SYN and AP	Definitely for the pitch. It would mess with my head a lot. Yeah, probably, because both synaesthesia and perfect pitch are linked. You'd be expecting a certain colour or characteristic and then it wouldn't be there. It would be quite confusing or baffling.
Xavier	SYN and AP	[Playing baroque violin] would definitely be weird, because hearing that semitone difference definitely messes with my head a bit. Definitely.
Benjamin	SYN and AP	I can't imagine playing a transposing instrument, not even when I compose. I like to compose with the [laughs] transposing thing off on 'Sibelius' so I can actually put the notes that I'm hearing in…if I was actually playing an instrument - reading and playing at the same time - I think I would find that too difficult.
Charlotte	SYN	I've been playing clarinet…The problem I found was that even though the clarinet faces another way, the fingers are very similar to flute and the sound is not what I expect. It's not so much the sound - it's the colour that's not what I expect. The pictures still happen to the sound or those shapes still happen to the sound that I expect from the flute, where it would be on the flute. And I find my fingers suffer because of that. I try to do what would feel natural for the flute and it's not on the clarinet.
Liam	AP	I've always been confused with talking to woodwind players or brass players by how they can read something and play something else. I don't understand how that can be called that note and how they can do it…I would be lost, I think. I would have to relearn a different way of approaching the instrument, I would think. But I've done that in some ways with baroque violin and classical violin. That's much less severe because it's closer than a perfect fifth or third or whatever it is that goes out. I find it's challenging.
Alexander	AP	I started piano and violin. I wanted to be a conductor and I still want to do conducting later on. But anyway, the conductor said to me, "Conductors are good with knowing the whole orchestra." They would have piano background, violin playing (they know how to play the violin), they know the piano and maybe a little bit of woodwind or brass. So I said, "Well, that's great. I'll learn one just for fun." So the trumpet was the first one that came into my head. Because trumpet is in B flat, and because I said earlier, C is do to me - it's very strong - I cannot stand reading a C in music and playing an open C, which

		sounds like a B flat. That perfect pitch really does not work with learning the trumpet. So after two months I quit and learned the trombone instead. So the trombone for one year: that was much better because the trombone is in C.
Max	AP	[Playing a transposing instrument, such as the trumpet, is:] Out of the question… I will not play on a forte piano or harpsichord that's tuned down because I just can't do it.
Cooper	AP	I think I would struggle quite a lot with that. [Pauses] I think it would have the same level of difficulty as someone transposing something that is written - so then transposing from that on your instrument: go. That's the same level of difficulty.
Henry	AP	I think I would really struggle with playing a clarinet in B flat. I would be like, "This is wrong! This is all wrong!"
Oliver	QAP	There was always a curious phenomenon with the keyboard where if I hit the transpose button, my fingers would kind of want to go to the patterns of the key that I'm hearing. This was a rich amusement to me because I'd be playing in C, hit the transposer to put it into E flat, and my fingers would just want to be in the space where E flat is and I'd laugh at myself. That would seem silly… I hated seeing the dot on the page that wasn't the sound I was hearing.

Appendix J.

List of 13 participants with AP or QAP who indicate perceiving individual notes as having distinct personalities or specific characteristics. A list of representative quotes is included; this list of quotes is, however, non-exhaustive. Note that 'synaesthesia' has been abbreviated to 'syn'.

Name	**Condition(s)**	**Comments**
Noah	AP	Personality: "I think they have a distinct character… C is boring like a really almost fake person. Then C sharp would be a mysterious neglected thing…" Gender: "possibly"
James	AP and SYN	Personality: "As well as a colour, they do represent some sort of personality for me" ("C major is like tofu! It's just boring to listen to").
Emily	AP	Colour: "Every pitch has a different sound. [Pauses] It's almost like a different colour." Feeling: "They have a distinctive feeling about them." Personality (tonalities): "The A major chord: the sound is much warmer than G major…I don't quite like F major because it's a little bit boring [laughs]. D is quite calming…C major - [pauses] is happy."
Sophie	AP	Texture: "all the notes have different textures." Temperature: "the warmth of each note…The black keys have their own character and it's a bit cooler than the white keys"
Joshua	AP	Colour: "I got a sense of E flat as a colour, not a visual colour but a timbre." Personality: "There are keys that I feel have more personality than others, I suppose. E flat would be among those, D, E maybe [sounding unsure]. I've got less strong feelings about F and G. They seem blander to me." … "what makes D different from E flat, they do have a different colour, but that colour comes from a different place in the scale"
Mason	AP and SYN	Colour: "I can feel the difference between C and D because I can feel that D is raising and it's a little bit brighter…I can feel a rising brightness as the pitches go higher…I'm expecting a certain brightness and resonance. That's not completely a synaesthesia thing."
Chloe	AP and SYN	Characteristics: "Could I articulate what those characteristics are? I could but the words would never be quite as finely attuned…A minor would be more plaintive and more personal; and D minor with greater depth and perhaps with wider societal ramifications of sadness. Both sad, but different sorts of contexts." Personality: Each individual note has a specific type of personality.

		Gender: “I suppose A minor has got to be more feminine, and D minor can be either. Some of the keys can be either and perhaps some more suited to others. I don't think that any are exclusively one or the other… keys can mould even if they might have a baseline stronger gender identification for me than others.”
Liam	AP	Characteristic: “The F sharp just above middle C - I will feel that the note itself is … more inviting perhaps, more comforting, more wholesome, more endearing. Or something about it makes it that I'm more drawn to that. Whereas the F sharp above at that particular pitch - it will feel less inviting and more sharp, for want of a better word.”
Amelia	QAP	Feeling: “When you'd play a C I would know it's a C…the C gives me a special feeling. It's a very neutral feeling. Some pitches like B flat are a bit sharp and very high.”
Zoe	AP	Temperature: “it feels a bit warmer when it's keys with sharps in it. And with flats in it it's colder”.
Samuel	AP	Characteristic (emotion): “I especially like concert E flat - E flat major. E flat's really nice” [This is the key he associates with beauty and purity]. “D minor I feel is more oriental, more Chinese-folk-melody-like.”
Max	AP	Characteristic (emotion): “a certain key or tonality will have an emotion attached to it… E flat minor will always be tense and always a little bit angry, restless, anxious: will always have a slightly uncomfortable element to it. So comparing to, let's say, F minor which is far more angry and full of rage I suppose. Same with D minor. It's a more direct anger I suppose… B minor is generally either restless or kind of withheld anger or deep inside.”
Henry	AP	Characteristic: flat keys sound more “mellow”, while sharp keys sound more “sharp”, or “aggressive” (this distinction only occurs for major keys).