Thinking in Sound: A Survey of Audiation in Australian Music Students

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Produced on archival quality paper
To the many who did not survive.
Abstract

Music and language are forms of human communication using sound. For millennia, playing an instrument has functioned in a similar way to language, as a means of communication and spontaneous expression of thoughts, emotions and ideas via sound. The way of acquiring that skill has paralleled the acquisition of language: through listening and copying.

The process of hearing and recognizing musical sound has parallels with thinking and understanding in language. Also known as audiation, this particular type of cognition is a fundamental aspect of traditional music performance expertise.

Relatively recently, in most formal education in Western cultures, the way of learning to play a musical instrument has changed radically. In place of listening-copying, the main way of learning and performing on a musical instrument is now almost uniquely through the visual symbols of notation. This new approach to learning to play an instrument is predicated on the idea that using notation renders musicians literate.

Some authors question this assumption, and suggest that many musicians may not be literate, because they are not audiating what they are seeing in notation. Rather, they may be decoding, using the visual cues of notation, or other non-audiation cues, to operate the musical instrument. This is thought to contribute to numerous problems in instrumental music learning. Other research is emerging that suggests some traditional musical practices may lead to more efficient audiation.

Although there is a great deal of conjecture about the issue of audiation and musical training, much of it is anecdotal in nature. Very little systematic research exists to confirm it. Although there is a wealth of research into many other facets of music performance expertise, we know very little about audiation in musicians or different training factors that may be associated with it.

The aim of this study was to investigate whether claims in the literature about audiation in trained musicians were supported by empirical evidence and what background factors may be associated with these abilities.

A survey of tertiary music students in all Australian states and territories was carried out in 2012-13. Responses were obtained from 340 students. Two tests of audiation ability were obtained as well as information about individuals’ learning background and pre-existing traits to examine what factors might be associated with audiation.

The findings confirmed some of the claims about limited audiation in trained musicians. Only one in four musicians were able to recognize and transcribe a simple heard melody. Without the benefit of perfect pitch, this figure fell to one in five.

Classical musicians performed better than popular musicians. Pre-existing traits such as perfect pitch, rather than formal training, appeared to be primarily associated with effective audiation. These results may provide some support for growing calls for a fundamental change to the teaching and learning of instrumental music.
Declaration

This is to certify that:

i. the thesis comprises only my original work towards the PhD

ii. due acknowledgement has been made in the text to all other material used

iii. the thesis is less than 100,000 words

Chris Sommervelle

Signed……………………..

Date………………………..
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There are, of course, many survivors...but it is a sombre thought that hundreds of thousands of people in this country...emerge at the end of their school days unable to play fluently (let alone sing)...unable to improvise, to transpose...to play by ear or notate correctly a known tune, or even to remember the four pieces they learnt for the exam last year... Something must be wrong (Bridges, 1984:71).
CHAPTER 1: INTRODUCTION

Background to the Study

Music and language are forms of human communication using sound. Numerous parallels and overlaps in the domains of music and language support the idea of music as a type of language (Koelsch, 2012; Mithen, 2006; Patel, 2008). As with language, instrumental music has for millennia functioned as a means of spontaneous expression of thoughts, emotions and ideas via sound. Until relatively recently, in every world culture, the way of acquiring instrumental music expertise has paralleled the acquisition of language: through listening and copying.

The ability to think in sound, recognize and understand musical sound, has parallels with thinking and understanding in language. Also known as audiation, this particular type of cognition is a fundamental aspect of the expertise of many famous musicians.

As with language, music has in recent times developed a written form in notation. This has allowed the representation of sound into graphic form allowing the ability to perform fixed versions of musical literature. Relatively recently, in formal education in Western cultures, the concept of music performance expertise has changed radically. In place of spontaneous musical expression, the goal of training has become the reproduction of pre-existing pieces from a select repertoire.

The way of learning to play an instrument has also changed radically. In place of listening-copying, the main way of learning and performing on a musical instrument is now almost uniquely through the visual symbols of notation. This recent approach to learning to play an instrument is predicated on the idea that using notation renders musicians musically literate.

There are numerous and ongoing claims that there may be some confusion surrounding the idea of musical literacy. Literacy implies an understanding of what is being read. There are numerous claims, however, that many people who use notation may not be audiating, but rather are decoding, restricted to using the visual symbols of notation as cues to operate the instrument (Bartel, 2006; Bridges, 1984; Gordon, 2007; Gruhn, 2006; Lehmann & Davidson, 2002; Seymour, 1910; Waller, 2010). To explain decoding in music, many people use analogies from verbal language. A person merely decodes, for example, when they learn to read and perform phrases from a tourist guide book without any understanding of the language, and without the ability for spontaneous expression.

In instrumental music performance, this lack of audiation may leave learners with difficulties in learning and performance, including being limited to playing only what is written, and without the fundamental musical ability of spontaneous musical expression (Bridges, 1984; Dobbins, 1980; Gordon, 2007; Gruhn, 2006). There are claims that this may be limiting enjoyment, and thus motivation and engagement for music learners (Gordon, 2007; Green, 2002).
CHAPTER 1: INTRODUCTION

Claims that a system of learning leaves many without fundamental musical cognitive skills are longstanding, frequent and ongoing (Dalcroze, 1928; Mainwaring, 1951; Seymour, 1910 for example). Such claims seem serious and worthy of attention, yet the issue appears to be of peripheral attention in the research literature on music performance expertise (Bartel, 2006; Gordon, 2007). Some researchers believe the issue is hidden from view, and that it would surprise many people to know that trained musicians may not be audiating what they are playing (Gordon, 2007). This is because decoding of notation, like reading from a tourist language guidebook, gives a superficial impression of music performance expertise.

In contrast to these claims, other claims are emerging that some kinds of musical practices develop more effective audiation. Musicians who mainly learn by listening and copying may develop more effective audiation (Green, 2002; Woody & Lehmann, 2010). This may allow them the ability of spontaneous musical expression as well as authentic musical literacy.

Problem Statement

Although there is a great deal of conjecture about the issue of audiation and musical training, much of it is anecdotal in nature. Very little systematic research exists to confirm it. There is a wealth of research into many other facets of music performance expertise, but we know very little about audiation in musicians or training factors that may be associated with it. This represents an important gap in our understanding of optimal approaches to acquiring music performance expertise.

Aim of the Study

The aim of this study was to investigate whether claims in the literature about audiation in trained musicians were supported by empirical evidence and what background factors might be associated with these abilities. The study reports on a survey conducted in 2012 and 2013 of the audiation skills of 340 tertiary trained musicians attending a music institution in Australia. The study aimed to answer the following research questions in relation to trained musicians:

1. What structural elements of melodic patterns are associated with audiation difficulty?
2. What degree of association exists between melodic pattern audiation and musical training?
3. What degree of association exists between melodic pattern audiation and pre-existing traits?
4. To what degree can melodic pattern audiation be predicted from training and pre-existing variables.
5. To what degree do trained musicians understand heard tonal music?
6. What degree of association exists between tonal understanding and melodic pattern audiation?
7. What degree of association exists between tonal understanding and musical training?
8. What degree of association exists between tonal understanding and pre-existing traits?
9. To what degree can tonal understanding be predicted from training and pre-existing variables?
In answering these questions it was necessary to select reliable and valid tests to measure tonal understanding and melodic pattern audiation. In order to enhance the interpretation of the statistical analysis, additional insights were obtained through analysis of information supplied on a researcher designed questionnaire.

**Scope of the Study**

The breadth and variety of human music making is almost infinite. The scope of this thesis is limited to an inquiry into instrumental music performance expertise primarily within the framework of the Western tonal music system; that is, a system involving musical tones that have a hierarchy of relationships, and where the tone or chord with the greatest stability functions as a tonal centre.

Instrumental music performance refers to a single musical instrument, including the human voice, or an ensemble of musical instruments. Instrumental music practices include spontaneous musical expression (improvisation), composition, performing pre-composed music, arranging and conducting.

The main focus of the study is on the relationship between instrumental musical training and audiation. Specifically, the question addressed is to what extent trained musicians have tonal understanding: the ability to hear or imagine tonal music and to understand it well enough to translate it onto an instrument or write it in notation? Because the focus is on musical training, the concepts of tonal understanding discussed may not be relevant to factors outside of musical training such as possession of perfect pitch.

The ability to translate a heard melody onto an instrument or notation usually requires some training in a comprehensive range of pitch skills including: hearing, memory, tonal understanding and a knowledge of notation (Karpinski, 2000:130). In contrast to this, as Karpinski (2000) observes, clapping a simple heard rhythm may not require any musical training, or knowledge of theory. Partly for this reason, and to limit the scope of the study, the main focus of this thesis is on the pitch aspects of tonal music: melody and harmony.

Another reason for excluding rhythm involves the important aspect of “feel”, the nuanced aspects of rhythm that bring music to life. As will be discussed further on, the minute variations of rhythmic emphasis and beat placement that create feel occur outside of explicit verbal consciousness presenting challenges to measurement and analysis that is well beyond the scope of this study. Therefore this study will focus primarily on the pitch aspects of the Western tonal system.

Gordon (1989) showed that tonal aptitude was not significantly related to rhythmic aptitude, and that it is rare for a person to have high levels of both. This may support the notion that the aspects of rhythm and pitch can be addressed as separate entities in this study without jeopardizing ecological validity.
Terms and Definitions

To facilitate the review of the literature, and later the discussion, the following is a collection of some of the key terms to be encountered, and their definitions, some of which are stipulative.

**Audiation:** A multistage cognitive process of organizing and predicting musical sounds, whether actual or imagined and giving them meaning. Often described as the musical equivalent of thinking in language. To standardize a plethora of terms, the word audiation will be used in this thesis as a general term when referring to cognition involving musical sound, whether real or imagined.

**Aural Musician:** A general term to denote a musician who learns and plays mainly “by ear”, that is, by listening and copying, with limited use of notation.

**Instrumental Music Performance Expertise:** The ability to perform music on a musical instrument including the voice. Also the ability to create music with an ensemble of instruments as in conducting, arranging or composing.

**Melodic Pattern Audiation:** The process of audiating differences or sameness between pairs of heard melodic patterns.

**Notational Audiation:** Analogous to language literacy. It allows a person to look at notation of Western tonal music and correctly imagine and hear internally (to audiate) the sounds of a tonal centre and scale degrees. Analogous to the activity of reading and understanding text.

**Popular Musician:** A general term referring to musicians functioning outside of the classical music genre. This may include jazz, rock, pop, blues as well as folk and traditional musics.

**Recitation:** Analogous in language to reciting famous literary works such as poems or speeches. Instrumental performance aimed at note perfect renditions of precomposed compositions. This may apply for example to performance of a big band jazz arrangement, a classical sonata or concerto, a transcribed rock guitar solo or musical theatre performance.

**Spontaneous Musical Expression:** Analogous to speech in language. Musical performance generated by expressing an imagined musical sound. The term is used here as an alternative for “improvisation” which is problematic for this study because improvisation can be generated by applying rules and formulas, or other non-audiation means, for example in the way speech can in a sense be generated by computers, but conversation can not.

**Tonal Understanding (TU):** A specific type of audiation. A three step sequential process of recognizing a tonal centre, perceiving melodic contour and assigning scale degrees of melodies. Tonal understanding may occur while hearing or imagining music, and while reading notated tonal music.

**Traditional Music Performance Expertise:** Used in this thesis to refer to instrumental performance based around spontaneous musical expression, and embellishment, in contrast to recitation of fixed note-perfect recitations of pre-composed repertoire.
CHAPTER 1: INTRODUCTION

**Transcription:** The activity of translating heard music onto notation. Also widely known as melodic dictation. The two activities are similar, but melodic dictation often involves a single, or very few playings, while transcription may involve numerous or unlimited playings. This thesis will use the word transcription as it adequately represents the real-life activities of translating heard sounds onto notation. It also avoids any potential verbal connotations of dictation.

**Overview of the Thesis**

In order to achieve the stated aim, Chapter 2 provides a background and context to the study and examines the extent and significance of the problem in more detail. Chapter 3 reviews literature on previous related research in audiation and tonal understanding. Chapter 4 reviews the methods other researchers have used to measure audiation in musicians. The chapter includes a review of some of the relative advantages and disadvantages of available tests of audiation. Chapter 5 describes the research design of the study. This includes the process leading to the design, the selection of instruments and the sample frame and recruitment of participants. The chapter concludes by explaining how the collected data was compiled and prepared for analysis. Chapter 6 reports on the results and analysis of the test of melodic pattern audiation: the Musical Ear Test (MET). Chapter 7 reports on the results and analysis of the test for tonal understanding: the Music Transcription Task (MTT). Chapter 8 discusses the significance and implications of the findings as they relate to theory and current practice. It includes a response to the research questions, a summary of the major findings and conclusions and ideas for further research.
CHAPTER 2: BACKGROUND TO THE STUDY

The broad question underlying this thesis is: what is the best way to become an expert musician. The specific focus of the study is on the fundamental cognitive skill that enables music performance expertise: audiation, the ability to think in musical sound. The thesis is a response to numerous claims about the effectiveness of current approaches to acquiring instrumental music performance expertise. Many of the claims centre around a lack of audiation in formally trained music students. Despite numerous and ongoing claims, there is a perceived lack of empirical evidence for them. The aim of this chapter is to examine the claims in more detail, and to clarify the extent and significance of the lack of available knowledge about this issue.

This chapter is structured in three main sections. The first section provides a context for the problem by presenting a brief historical review of human music making and the deeply intertwined relationship between music and language. This will allow an explanation of two distinct forms of music performance expertise which can be likened to the difference between spontaneous speech and reciting famous literary works. The final section of the chapter outlines the significance of the problem by comparing the importance of audiation in music with the importance of thinking in language.

Overview Of Music Learning

In order to consider the best way to become an expert musician it is necessary first to define musical expertise. In numerous domains such as the sports, games and sciences it can be relatively straightforward to define expertise. A problem inherent in music, and the arts in general, is that accurately defining performance expertise is difficult if not impossible. This is partly to do with a general lack of consensus in defining not only music but expertise. Added to this is the intractable problem of trying to define creativity.

A core assumption of this thesis is that music expertise along with all other human behavior, is a manifestation of brain activity. Although skill acquisition in the arts is not usually framed in biological terms, at a fundamental level learning to master any task occurs through brain plasticity: effecting changes in the underlying functional anatomy of the brain (Goldberg, 2009:287). For the purposes of this thesis, the brain is an organ of information processing. It evolved, like our other organs, through selection pressures during the stone age which comprises 99.9% of human existence. The brain gives rise to the mind, which may be viewed as:

a system of organs of computation, designed by natural selection to solve the kinds of problems our ancestors faced in their hunter gatherer lifestyles, in particular, understanding and outmaneuvering objects, animals, plants, and other people. (Pinker, 1997:21)
The Music Language Continuum

Millennia of music making appear to have shaped our brains so that we possess neural mechanisms dedicated specifically to processing musical information. Research into the brain and music suggests strong support for the idea that there is a biological basis for musical behavior (Edwards & Hodges, 2007).

The relationship between music and language, and their role in human evolution, has become the focus of increasing research interest (Bannan, 2012). Music and language are human universals, evident in every known civilization and most likely in all prehistoric societies (Mithen, 2006). Both activities play a fundamental role in human existence. Both activities involve making sense out of sound, a highly complex process of converting sequences of sound, organizing them into hierarchical structures and extracting rich meanings. Some universals in music have led to speculation that music and language may have emerged from a single ancestor: a “musilanguage” (Darwin, 1871; Mithen, 2006; Patel, 2008), and that the first human language may have been a kind of song (Mithen, 2006:26).

Extensive evidence at the neurobiological and neuropsychological level suggest there are numerous similarities, parallels and overlaps between the human language system and the music system (Koelsch, 2012; Patel, 2008). Every human brain comes equipped at birth with two separate sound processing systems: a musical system and a linguistic system. The language system comes with vowels, consonants and pitch contrasts; the musical system includes timbres and pitches of the culture’s music (Patel, 2008:9). By the time we are born we are already highly skilled at processing, grouping and differentiating between sounds (Koelsch, 2012:245). There is ample evidence to suggest that music is as natural for humans as is language (Shuter-Dyson, 1999:645)

The two activities share a significant number of identical characteristics or design features such as being structured according to a syntactic system (Koelsch, 2012). The two systems share common features such as vocal utterances, prosody and expressive phrasing. They also share similar features that may be more typical for one system than the other. These similarities overlap at transitional zones along a continuum (Koelsch, 2012:245).

Rhythm for example is usually thought of as an important feature of music but rhythmic elements play an important role in numerous kinds of speech in many world cultures. A regular pulse or beat can often be found in poetry, ritualistic speech and emphatic speech such as preaching and oratory. This kind of speech sometimes borders on song and the use of pitch and rhythms can make it difficult to define whether someone is singing or speaking (Koelsch, 2012). Musics like rap and operatic recitatives also stretch the boundaries between speech and music.
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Pitch information is another surprisingly important aspect of language as it conveys a great deal of emotional nuance. All languages use variations in pitch (intonation) to code emotions, phrase boundaries, questions, and imperatives. Pitch information is also particularly important with tonal languages where it codes word meaning and grammar. The musical aspects of language—melody, metre, rhythm and timbre—are crucial for babies learning a language. Infants use these musical cues of speech to detect word and phrase boundaries, and possibly meaning (Koelsch, 2012).

A review of existing studies suggested that because infants do not yet understand words, they may perceive the voices of others musically (Brandt, Sleve, & Gebrian, 2012). Koelsch (2012:245) proposes that some research suggests that the brain, especially when young, does not separate music and language into strictly separate domains, but rather treats “language as a special case of music” (Koelsch & Siebel, 2005). These and numerous other crossovers and overlaps are extensive enough to suggest that music and language may not be separate entities but rather “different aspects, or two poles, of a single continuous domain” (Koelsch, 2012:244). Koelsch (2012:244) refers to this as “the music-language continuum”.

Music Performance Expertise

The close relationship between language and music suggests similarities in how the two things are acquired. Throughout most of human history, in every world culture, music has been acquired in a similar way to language expertise: largely effortlessly without formal intervention via extended enculturation and active participation often framed in playful interaction (Campbell, 1991; Hargreaves & North, 2001; Mithen, 2006; Woody & Lehmann, 2010). Music is learned by passive childhood acquisition: “they just listen and learn” (Mithen, 2006:15).

To this day, in most world cultures the primary mode of acquiring music performance expertise remains listening, copying and imitating. Throughout the world, most religious music, and folk and traditional musics are founded on listening-copying processes. In Africa in many traditional cultures music learning starts in the womb and from birth children are exposed to music and movement. Often there is no clear distinction between music and language or between musician and non-musician (New, 1983).

For those musics descended from African origins: blues, soul, rock, reggae, salsa, hip-hop, gospel, pop, jazz and so on, listening and copying remains the principal means of acquiring and transmitting musical skills. In the Middle East, India and Asia, most musics are based on aural tradition. Expertise in most traditional folk musics as well as the technically demanding classical musics (of, for example, India) is acquired mainly by listening and copying, and by observing teacher demonstration; compositions are learned phrase by phrase by listening to and copying the teacher's performance (Campbell, 1987).
In most of these musical cultures music performance expertise shares strong parallels with language expertise. As with speech, music is considered to be a flexible medium of spontaneous expression of thoughts, emotions and ideas. Expertise includes the ability to freely manipulate the elements of music as a means of spontaneous expression. In most of the world’s musics, spontaneous expression in improvisation and embellishment are integrated throughout the music. For this reason a major aspect of musical training in many world traditions involves developing and refining musical aural skills: the ability to hear or imagine music in order to copy and embellish it, or engage in spontaneous musical expression. In many Asian musical traditions, vocalizing of musical material being learned is an important part of the process. Instrumentalists and particularly drummers are required to sing their parts before attempting to play them on the instrument (Campbell, 1987).

**The Western Classical Tradition**

The Western classical music tradition was no exception to these principles, and evolved from the same listening and copying practices as observed across the rest of the world. Until the development of notation, music existed only as sound and was created spontaneously (Campbell, 1989). The tradition was transmitted by listening and copying (Campbell, 1989). Until the Renaissance, music performance expertise was acquired largely informally by listening and copying. Beginning with the Renaissance, instruction became increasingly formalized and notation began to be more widely used. Even at this stage, however, notation functioned mainly as a guide, much like today's melody and chord sheets of popular music. Performance and learning were based on an aural tradition. For this reason, as in many other musical traditions, training continued to emphasize the development and refinement of aural skills. Before beginning to learn an instrument renaissance musicians first had to learn to sing and to improvise vocally on a cantus firmus (Campbell, 1989).

As in most other music cultures, in the Western classical tradition expertise comprised the capacity for spontaneous musical expression. Many of the learning and performance practices bear a striking resemblance to those of modern-day popular musicians (Gould & Keaton, 2000). Spontaneous musical expression in improvisation and embellishment were integrated throughout the music in both learning and performance (Gellrich & Sundin, 1993; Gould & Keaton, 2000). Orchestra musicians played their parts by ear, improvising the accompaniment. Baroque musicians learned to improvise an accompaniment using figured bass.

Many famous musicians from the Western classical tradition were not just expert composers but were also renowned for their spontaneous musical expression abilities. Virtuoso displays of spontaneous musical expression were pervasive throughout the Western music tradition (Campbell,
Recitals by virtuosi usually included extended improvisations that were an eagerly anticipated part of concerts. The prodigious nature of these feats is perhaps best exemplified by Bach’s ability to improvise multi-part fugues. Many of the great works of the Western classical canon began life as these kinds of improvisations.

There is scarcely a single field in [Western] music that has remained unaffected by improvisation, scarcely a single musical technique or form of composition that did not originate in improvisatory practice or was not essentially influenced by it. (Ferand, 1961:5)

**Current Practice: Formal Music Education**

The widespread emergence of printed notation from around the late 1800s revolutionized the traditional conception of music performance expertise (Campbell, 1989:37). From around this time, classical composers began to fix the structure and form of their compositions and almost every detail became carefully notated. Cadenzas, which had once been opportunities for performers to demonstrate their spontaneous expressive skills, were now written out in full. Classical music became “frozen in time” to be rendered in note perfect form (Campbell, 1989:38). Instrumental expertise became increasingly viewed as an activity for communicating the creative ideas of the composer. A performer's individual interpretation or self-expression was de-emphasized, and the prominent role of improvisation as part of music performance expertise gradually waned.

The emphasis on notation led to a major bifurcation in the general conception of music performance expertise. While in most world cultures music remained a vehicle for spontaneous musical expression, the Western classical tradition became focused on the ability to learn and play note perfect renditions of pieces composed by others.

Today in most formal music education institutions around the world, the goal of training is to refine the technical skills required to execute note-perfect renditions of complex pieces from a select repertoire. Schools, which feed into higher education institutions, have also embraced this conception of music performance expertise. In the United States and many other countries, at secondary school level, instrumental music learning is almost exclusively based around performing precomposed works in ensemble formats (Campbell, 1989; Green, 2002; Woody & Lehmann, 2010).

**Notation**

With the change in conception of music performance expertise, formal approaches to acquiring it have also changed radically. In most formal settings traditional listening-copying practices have largely disappeared. These have been replaced by the visual image of notation which is now central to learning, teaching and performing. Once instrumental music lessons have begun: “almost all the instrumental activity thereafter, in lessons, rehearsals, concerts and examinations,
consists in reading while playing” (P. Priest, 1989:173). Learning is centred around verbal instruction and includes the learning of technical and theoretical concepts.

Listening-copying activities have not only become marginal to most formal music training, they may be actively suppressed or discouraged (Campbell, 1989; Green, 2002; T. Priest, 2002; Woody & Lehmann, 2010). “Students are dependent upon their visual sense, and orality is minimized by the teacher” (Campbell, 1989:39).

This learning approach has also been applied to some musics which have until recently been based in listening-copying. Musics from the listening-copying tradition such as jazz and pop have in recent years entered many formal learning settings (Green, 2002; Woody & Lehmann, 2010). Once absorbed into these settings, the learning and performing practices may resemble classical models, with performers reading from notation and ensembles being directed by a conductor. “Ear playing is still largely absent, and improvisation is presented as an optional or, worse yet, an odious exercise” (Woody & Lehmann, 2010:113).

Learning instrumental performance in most formal settings is approached in much the same way that we might learn and recite a famous literary work. Music learned in this way is often presented in the form of a “recital”. In language expertise, we make a marked distinction between the ability to recite pre-composed text from the ability of spontaneous expression. For the purposes of this thesis, a similar distinction will be observed for music performance expertise. The term “reciting” will be used to refer to music performance expertise that aims at a fixed reproduction of pre-composed music. This is to distinguish it from the skills of spontaneous musical expression.

Music Literacy
Current formal approaches to acquiring music performance expertise are predicated on the notion of music as a kind of language. As with verbal language it is considered essential to develop literacy. A major assumption underlying much formal music training is that learning and playing via notation renders musicians “musically literate”, able to understand and read and write music the way we read and write verbal language. The term music literacy is often used in the context of learning and performing music from notation to distinguish it from traditional aural or oral practices. For example, Campbell (1989:37) writes, “orality in the West was eventually superseded by literacy”.

Audiation: Thinking In Sound
The writings of numerous famous expert musicians from the Western classical tradition including Mozart, Schumann, Berlioz, Wagner and Tchaikovsky indicate that their expertise included this kind of musical literacy (Agnew, 1922). A heightened ability to recognize and mentally manipulate musical sound allowed expert musicians to recognize complex music that they
heard, or imagined (or in some cases dreamed) and to understand it in order to write it down in notation or to play it on an instrument in spontaneous musical expression (Agnew, 1922). Conversely, it allowed them to read complex notated music and to internally hear and understand it in a similar way to reading verbal text.

Numerous terms exist to describe the cognitive ability to mentally imagine and manipulate musical sound. Many terms imply a process similar to visual imagination: such as musical imagery, aural imagery, aural imagination, auditory imagery and auditory musical imagery. Gordon (2011) found that the use of imagery terminology for aural processes was the basis of some confusion. He found many people overlooked its intended aural sense, instead identifying it with the visual stimulus of notation, or confusing it with the visual images provoked by certain types of music.

Other commonly used terms to describe music cognition are based on the idea of hearing or ear. These may include inner hearing, aural acuity or aural discrimination. It is common among musicians to describe a musician as having “good ears” (see Barenboim, 2012 for example).

Cases of expert musicians with severe hearing impairment, however, suggest that this kind of terminology may also be misleading. Beethoven is considered one of the greatest improvisors and composers of the classical tradition. It is striking that he continued to compose some of his greatest works long after losing the ability to hear any external sounds. Sacks (2008:32) attributes Beethoven’s (and others’) expertise to “musical imagery” which Sacks defines as “music that plays in our heads” (2008:32). This is, however, an incomplete explanation. Most people have experienced some form of music playing in their heads either voluntarily or involuntarily. Yet most people are not expert musicians. This is because they are not able to translate what they are hearing onto an instrument or onto notation the way Beethoven and other expert musicians are.

Music performance expertise in the case of Beethoven and other expert musicians involves not just hearing music that plays in our heads, but an important further step of recognizing and understanding what is being heard or imagined. This allows musicians to reproduce or manipulate the heard or imagined sounds.

For this reason many terms for music cognition invoke parallels with language cognition such as thinking and comprehending. These may include: musical understanding; thinking in sound; making sense of music; thought representation of music; creative thinking in sound; aural comprehension; auditory musical reasoning; music mentation; tonal cognition; and metaperception of music. The wide variety of terms suggests some difficulty in precisely defining this particular form of cognition.

Despite the wide variation of terms, a common thread running throughout is the idea, parallel to expertise in language, of comprehension and communication of what is being heard. Listeners who understand music either heard or imagined are said to be “thinking in music” (Karpinski, 2000:4). Seymour (1910:preface) acknowledged the limitations of this kind of
terminology to describe musical processes: “The inward process of listening and hearing is not adequately expressed by the word think, but it seems to be the best term descriptive of the process that the English language affords”. Despite their inadequacies, “thinking in music” or variations thereof are widely used terms.

Gordon (2011) noted that although many performers and teachers were aware of this cognitive skill, they lacked vocabulary to describe it, and did not understand how it developed. To address the lack of suitable terminology—and particularly to avoid the concept of imagery—Gordon developed the word “audiation”.

Audiation occurs: “when we assimilate and comprehend in our minds music that we have just heard performed or have heard performed some time in the past...[and/or] that we may or may not have heard but are reading in notation or are composing or improvising” (Gordon, 1998:12). Gordon (1998:12) makes a clear distinction between this and musical imagery: “Audiation is a more profound process. Musical imagery...does not require the assimilation and comprehension of the musical sound itself, as does audiation”. Audiation in music is analogous to thought in language. It provides meaning to music as it is performed, read, or written (Gordon, 2007).

Audiation is a useful term to standardize the wide range terms for the cognition of musical sound. For this reason, this term will be used in this thesis when referring generally to cognition involving musical sound, whether real or imagined. But although audiation is a useful term, it is unfortunately also a blanket term covering a wide range of types and stages of music cognition. A more specific term is required to describe the process by which musicians are able to understand heard music, and to hear and imagine music while reading notation.

**Tonal Understanding**

Although there are numerous types of understanding in music, Karpinski, (2000: 78) divides musical understanding into two main sections: rhythmic and tonal. This thesis will focus mainly on the tonal aspect of understanding within the Western tonal music context.

The Western tonal music system is based on a system of seven tones (a scale) which gravitate towards a stable, central tone. The individual tones each bear a particular and identifiable sound characteristic in relation to the central tone, and to each other. Most tonal music in Western cultures begins and ends on the tonal centre. In tonal music, most melody and harmony in Western music cultures is based on almost infinite permutations of these seven notes, and their relationship to the tonal centre.
As well as existing as a set of sounds, the seven tones of the scale can also be represented in a variety of ways. The individual tones can be represented with a system of verbal labels. This may include numbers from one to seven, with one being the central tone. They can also be represented with solfege labels, with Do being the central tone.

The scale can also be represented visually in music notation or as a graphic representation of the keys of an instrument such as a keyboard. (See Figure 1).

Karpinski (2000) has described the process by which expert musicians recognize and understand the relationships of the tones in a passage of tonal music that they hear or imagine. This understanding is a “unique stage of music perception” (Karpinski, 2000: 78) that involves “comprehension of relationships” between musical tones. Karpinski, (2000:95) terms this process as “understanding of tonal function” and suggests that within the field of Western formal music training, this cognitive skill is “central, indispensable, and predominant”. For ease of terminology, I will use the term tonal understanding when referring to the specific process of recognizing and understanding the pitch content of tonal music.

Karpinski (2000) has described a very specific three-step sequential cognitive process by which expert musicians achieve tonal understanding. Step one is to establish the tonal centre. Step two is to perceive the contour of melody. Step three is to identify and label the scale degrees of the melody tones (Karpinski, 2000:82).

**Tonic inference**

The first step in understanding the pitch content of a passage of music is to establish the tonal centre of what is being heard. The ability to infer the tonal centre is crucial for genuine musical understanding, as it is “the very frame of reference at the heart of tonality itself” (Karpinski, 2000:82). “All functional pitch evaluations stem from a sense of the tonic” (Karpinski, 2000:82). Understanding where the tonal centre is, allows a musician to determine “scale degrees, harmonic functions, modulations, and a host of other tonal features”.

![Figure 1: The Western Tonal Scale](image)
Perception of melodic contour

After establishing the tonic, the next step is to determine melodic contour: the change in pitch—higher or lower—between successive tones. This requires that listeners retain a melody in short term memory (Karpinski, 2000:48). Determining melodic contour is a vital step in music understanding. Without the ability to identify contour, listeners will have great difficulties identifying scale degrees associated with its pitches, which is the main activity in music understanding (Karpinski, 2000:48).

Identification of scale degrees

In tonal music, the place of a note in a scale gives it a particular tonal function (Dowling, 1986). Musical meaning is conveyed by this tonal function. Therefore, for musicians to effectively perceive melodies, they need to do more than recall the contour of melodies. They need to understand the relationship of pitches as they function in the tonal system (Karpinski, 2000:95).

A simple example of tonal understanding can be achieved by imagining the melody of Twinkle Twinkle Little Star.

Step 1: Humming or imagining the first few notes of the melody, a listener recognizes that the tonal centre of the tune is the starting and ending note. It is the tone to where the melody gravitates.

Step 2: Listeners recognize that the contour of the melody rises in two steps before descending in a series of steps to the tonal centre.

Step 3: Listeners assign labels to the steps of the contour. The melody tones could be labelled with numbers: 1-1-5-5-6-6-5; 4-4-3-3-2-2-1, or solfege terms: do-do-so-so-la-la-so; fa-fa-mi-mi-re-re-do.

On hearing or imagining this, or any other simple tonal melody, a person with tonal understanding would recognize the relationships between the melody tones and the tonal centre and be able to translate it onto a musical instrument, or if trained in notation to write it down. Conversely, a person with tonal understanding is able to read the notated melody and to imagine and hear the sounds internally, as when reading verbal text. This process of recognizing notated music is also known as notational audiation. Tonal understanding and notational audiation are integral to musical literacy.

Audiation As Music Performance Expertise

A large amount of literature from a wide variety of sources emphasizes that audiation is the foundation of music performance expertise. Although the terminology used throughout the literature varies widely, it is an important assumption of this thesis that it usually refers to what Gordon (2007) defined as audiation: the ability to think in sound. The terms “aural skills”, or “musical imagery” or “musical ear” are in themselves quite vague if not meaningless. This is more
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evident in verbal language, where an evaluation of competency is unlikely to include a discussion of a person’s “aural skills” or “ear”. Generally, what is important is comprehension: whether there is understanding of the language and the ability to use it to communicate. Therefore, although it is only a recent word, in the interests of standardizing the plethora of terms, the word audiation will be used when referring to “aural skills”, “ear training” and similar terms.

References to the importance role of audiation in music performance expertise are longstanding. In the 18th century Swiss educator Johann Pestalozzi advocated the importance of developing audiation through listening and copying rather than reading notation and in the early 19th century these principles were adopted by Lowell Mason an important figure at the beginning of American formal music education (Abeles, Hoffer, & Klotman, 1994:11). Composer and pianist Robert Schumann believed that “inner listening” was a crucial skill, and that “developing the ear is of the utmost importance” (in Karpinski, 2000:9). A good musician is one, “who understands the music without the score, and the score without the music. The ear should not need the eye, the eye should not need the (outward) ear” (Agnew, 1922:280). Piano pedagogue Leimer believed a performer should be “able to hear the music [of the score] with one’s ‘inner ear.’” (in Gabrielson, 1999:505). Seashore (1919:161) described “auditory imagery” as “perhaps the most outstanding mark of the musical mind”.

Numerous pedagogues including Kodaly, Orff, and Suzuki all proposed developing audiation as the foundation of music performance expertise. Analysis of the writing of numerous psychologists, musicians and researchers revealed a central concept: “musical imagery, or aural imagery, is the most important aspect, if not the basis, of music aptitude, or what they commonly referred to as musicality, musical talent, and musical giftedness” (Gordon, 1998:19).

Audiation is seen as “extremely valuable while listening, performing, studying, conducting, composing, and teaching” (Karpinski, 2000:73). It is “the foundation of musicianship” (Gordon, 2009) and “fundamental to music aptitude and, consequently, to music achievement” (Gordon, 2007:46). It is a “major component” of music performance expertise (Gabrielson, 1999:502), and “integral to musical craftsmanship” (Schneider & Godoy, 2001:22) for performers, conductors, and particularly for composers and arrangers in making predictions of how their compositions will sound.

Many researchers note the importance of audiation in creative music performance expertise (Bridges, 1984; Campbell, 1989; Dalcroze, 1928; Field, 1979; Gordon, 2001, 2007; Green, 2002, 2008; Kratus, 1990; Leong, 1999; Mainwaring, 1941, 1951; P. Priest, 1989; D. Williams, A, 2007). Audiation is “not only relevant for the professional musician, but also for music education at all levels” (Schneider & Godoy, 2001:22). “Musical competency requires students to develop audiation skills in order to aurally represent in their minds what they see, hear or wish to create on their instrument” (McPherson, 2005:10). The importance of developing audiation for music performance expertise is widely acknowledged.
Claims About Audiation Pedagogy

The important role of audiation in music performance expertise is also widely acknowledged in formal music education. Some form of “aural training” or “ear training” designed to develop “aural skills” is usually present in almost all music curricula from early childhood to tertiary music institutions around the globe.

Although some kind of aural training exists in most formal music education, many researchers question its effectiveness in developing tonal understanding (Bridges, 1984; Odam, 1995; Pratt, 1998; P. Priest, 1989; Stowasser, 1997). Gordon, (2007:9) claimed that music students are taught the elements of notation and music theory without tonal understanding. He defined common-practice music theory as “ignorance of audiation glorified and reduced to a system”. He claimed that “the aural/oral level in music education is so rarely taught that there are relatively few persons who value music through understanding” (Gordon, 2007:100).

Seymour (1910) also claimed that most formally trained music students were not taught to audiate. Mainwaring (1951) believed music performance expertise was most effectively trained by developing audiation. But he claimed that most instrumental teaching encouraged a mechanical approach to producing sound by decoding rather than genuine audiation. Bridges (1984:70) believed that formal education does not allow students to properly develop “conceptual understanding” of the music they are trying to play.

A survey into aural training by Pratt (1998:1) found, “an alarmingly large proportion of musicians, questioned about their own experiences of aural training, admit that they disliked it, thought they were bad at it, and have found it largely irrelevant to their subsequent engagement in music. Something is clearly wrong”. Pratt claims that “most conventional aural training is quite inadequate” (1998:vii). Another review of aural pedagogy (Butler, 1997:43) found:

Aural training is still a patchwork in American colleges and universities. It is a pastiche of observable behaviors that may or may not link directly and consistently to a corresponding set of aural skills. But we don't know exactly how these behaviors map across these skills. In fact, aural training practitioners can't even come to full agreement on what skills they'd like the successful students to possess when they exit the aural training course sequence. (Butler, 1997:43)

Jeanneret, Leong and Rosevear (2003:7) reviewed aural pedagogy in formal music education and found: “it would appear that music teachers have long struggled to develop the critical aural perception skills needed by all musicians”. They concluded that “there is a rather ad hoc approach to the whole aural pedagogy issue” (2003:7).
Anecdotal Claims

The Jeanneret, Leong and Rosevear study (2003:7) was prompted by anecdotal evidence and personal observations by the researchers that there were problems with aural pedagogy. Concerns about aural skill pedagogy flow on to widespread, ongoing claims that many formally trained music students are left with limited audiation. The anecdotal nature of many of the claims is a recurring feature in the literature.

“Stories exist” of music students who can play a complicated concerto for an audition, but who subsequently demonstrate an inability to recognize simple intervals (Brown, 1990:1). And, “ear training instructors report large numbers of students, including fine performers, who aurally comprehend little of the music they read and hear” (Brown, 1990:1). Brown (1990:1) claimed that “many college music majors comprehend little of the music aurally which they study or perform. Theory instructors express frustration at music students' poor aural acuity, and students lament their inability to master aural skills”. Jeanneret, Leong and Rosevear, (2003:6) suggested that “many tertiary students seem to struggle with their aural courses but somehow they survive sufficiently to pass and move on”, even though “few could be said to have mastered the...ability to ascribe meaning to sound”. Leong (1999:128) claimed that:

unfortunately music teachers know that aural comprehension is grossly lacking amongst most of our music students. Many struggle to aurally perceive very basic rhythmic patterns, intervals, melodic patterns and chords...the sounds produced are often...devoid of aural comprehension and hence musical comprehension.

Numerous tertiary music institutions report that incoming students “often suffer from deficiencies in aural skills” (Karpinski, 2000:7) (See also Denson, 2010; Wennerstrom, 1989; Woody & Lehmann, 2010).

Problems have been identified in some approaches to acquiring instrumental music performance expertise. Many of the claims suggest a lack of audiation may leave learners with difficulties in learning and performance, including being limited to playing only what is written, and without the fundamental musical ability of spontaneous musical expression (Bridges, 1984; Dobbins, 1980; Gordon, 2007; Gruhn, 2006). There are claims that this may be limiting enjoyment, and thus motivation and engagement for music learners (Gordon, 2007; Green, 2002).

The wide variety of terms used to discuss the phenomenon is noteworthy and may suggest a lack of clarity in this area. Some of the claims are unequivocal. Gordon (2011:9), described a “paucity of school graduates’ musical understanding”, and claimed that “practically none” can improvise or audiate harmonic chord changes of the music they listen to or perform. He also
claimed that “most students and probably most musicians” lack an understanding of the music they play (Gordon, 2007:11).

**Music Literacy Claims**

Although the term music literacy is used widely throughout music education, it is perhaps surprising that there is almost no useful research on the topic (Bartel, 2006; Hodges, 2002). There are numerous research studies on sight reading notation but they are not supported by any specific theoretical basis (Hodges, 2002:468-469).

Reading notation differs from language reading. Literacy in language usually is thought to include an understanding of the meaning of the text. In music however the idea of meaning is currently not well understood making it difficult to accurately define music literacy. Therefore the ability to read notation is not necessarily the same as music literacy.

Many authors emphasize that the important aspect of music literacy is an understanding of what is being read. As Robert Schumann described it, “You must get to the point that you can understand music from the page” (in Karpinski, 2000:3). There has long been some consensus that notational audiation functions in a similar way to verbal literacy. A musician reading notation is thought to be audiating the sound it represents, and conversely, when audiating heard musical sound being able to visualize it as notation (Gordon, 2007). Yet until recently there has been almost no research investigating this assumption and the processes underlying notational audiation are not well understood (Brodsky, Kessler, Rubinstein, Ginsborg, & Henik, 2008).

Many authors strongly question the widespread assumption about music literacy. Bridges (1984) suggests there may be some confusion surrounding the notion of literacy as it refers to music performance expertise:

Although we make many assumptions about music literacy, there are some widespread misconceptions concerning its nature, the processes of acquiring it, and its role in music education. One problem arises because we interpret the words 'music literacy' too literally! The dictionary defines literacy as 'the ability to read and write'. Applied to language, this definition surely implies comprehension, so that what we read or write has some meaning, and is not simply a matter of pronouncing or copying words. Music literacy too involves reading and writing, using music's symbolic system. But unless there is aural comprehension as well—the ability to form mental images of the sounds represented by music notation—we cannot claim to be musically literate. (Bridges, 1984:70)

There are many claims that many formally trained musicians lack an understanding of the music they play leaving them effectively musically illiterate. Bridges (1984:70) claims “all too often
CHAPTER 2: BACKGROUND TO THE STUDY

[music students] are musically illiterate because they have by-passed the aural process and have not internalised what they are reading, playing, or writing”. Campbell (1989:31) notes that while the printed symbols of notation may indicate which fingers to use, “the associated aural understanding is often overlooked or reduced to an adjunct objective”. Field (1979:47) wrote that many tertiary music students develop what he calls “athletic skills” without developing musical understanding.

That a system of learning designed to endow literacy in fact leaves most learners illiterate seems to be a very serious claim. Yet such claims about formal music education are frequent and ongoing. It is perhaps surprising that there appears to be a relative lack of concern about the situation. One explanation is that the situation may be in some ways hidden from view. It is possible that many people might be surprised to find that even highly trained musicians have more limited audiation than might be expected. The obscure nature of the issue is noticeable in some of the language used to discuss it. Gordon (2007:396) for example, believes that problems of poor audiation development identified more than a century ago continue to go unrecognized. He asked:

Would it surprise you to learn that the majority of college-age students who enter and graduate from music schools do not have the ability to translate what music notation sounds like unless they or others first perform it on a music instrument? (Gordon, 2001:1)

Serafine (1988:234) commented that learning to recite music on an instrument is much less likely to develop effective audiation than many people might expect. The full extent of this issue may be partly obscured because instrumental performances can be generated from very distinct mental representations.

**Mental Representations**

According to several recent theories all mental activity including music performance expertise is enabled by the brain’s ability to organize information into abstract mental “representations” (Gruhn & Rauscher, 2002; Kosslyn & Koenig, 1992; Lehmann & Davidson, 2002; Snyder, 2000). The exact nature of these representations, and how they are formed in the brain is still seen as extremely complex and still an unresolved concept in cognitive psychology and philosophy of mind (Edwards & Hodges, 2007; Snyder, 2000). Mental representations are nevertheless seen as a crucial component of learning and key concept in skill and expertise research (Gruhn & Rauscher, 2002:447; Lehmann & Davidson, 2002:545). Contemporary psychological theory suggests that different types of representations can be formed for the same thing (Lehmann & Davidson, 2002:545). Snyder posits these representations may exist as types of “images”: not only visual but also may include sound and smell. They make up a basic “picture” of the world in which long term memories may be encoded (Snyder, 2000:23).
When a musician encodes or manipulates musical information, they form mental representations (Lehmann & Davidson, 2002:545). These might include an auditory representation of the sound of a melody, a visual representation of the notation or a motor representation as to how to execute it on an instrument. Music learning has been defined as the process of incrementally developing these representations, and then gradually altering, extending and refining them (Gruhn, 2006:17; Gruhn & Rauscher, 2002:449).

Davidson, Scripp and Welsh (1988:69) commented that formal instrumental music training “surprisingly…does not build an internal representation system which can be used independently of the instrument”. Webster and Richardson, (1994:11) for example note that a trumpet student playing a piece by reading from notation may not be audiating but rather, “may just be pushing buttons and tightening the embouchure”. On the other hand, a trumpet player performing the same piece with tonal understanding may also be able to improvise and embellish and transpose. At a surface level the two performances may sound similar, but may be “mediated by distinctly different underlying mechanisms” (Lehmann & Ericsson, 1997:50).

To explain this distinction in types of musical representations, many authors use analogies from language expertise. A frequent comparison is of someone fluent in a language compared to a tourist who rote learns phrases from a guide book. Although there might be a superficial similarity in the produced phrases, the tourist would be unable to understand or converse or otherwise express themselves in the language. The underlying mental representations used to produce the phrases are likely to be quite distinct (Lehmann & Davidson, 2002:546).

Authors distinguish the act of reading from that of decoding. Gordon claims that most formally trained musicians are effectively illiterate: “Essentially, they only decode, not truly read, simply by pushing keys or valves on an instrument. The analogy is knowing the alphabet but not being able to give meaning to written words or sentences” (Gordon, 2001:1). Gruhn, (2006:21) claims that most formal music training currently focuses on the musical equivalent of rote learning from a phrase book. “This can be compared to a person who memorizes an Arabic poem with authentic pronunciation but without any ability to understand and speak the Arabian language”. This is “analogous to typewriting material without understanding the language” (Schleuter, 1984:22).

Woody and Lehmann, (2010:112) claim this lack of understanding may extend to highly skilled performers who in place of musical understanding “rely on musical notation and use it as a cue for fingerings or other bodily actions needed to play an instrument. Keyboardists may become especially dependent on such an approach”. Lehmann and Davidson (2002:546) give the musical example of “Chopsticks” and suggest that “many people can play [“chopsticks”] on the piano even without training. It requires mere visual orientation and hitting black or white keys and counting up to six”. Many researchers claim that many trained musicians are capable of little more than advanced versions of “Chopsticks”.
Popular Music Claims

There are also claims that there may be differences in audiation competencies between different genres of musician, and between different learning approaches. Some evidence is emerging that some music learning approaches may be more effective in developing music understanding skills. Research has identified a stratum of musicians who follow traditional music learning approaches (Green, 2002). “Popular” or “vernacular” musicians operate largely independently of formal music education, forming self-organized groups to perform contemporary popular music or various folk musics. These largely self-taught musicians learn mainly by listening-copying of real music, and play mainly by ear (Green, 2002; Woody & Lehmann, 2010). Learning and performance includes improvisation, embellishment and the creation of original compositions by ear (Green, 2002; Woody & Lehmann, 2010). As with most aural learning, “notation is used only as a means to an end, never for its own sake, rarely to analyse music, for that is done aurally, and rarely to learn a new piece, for that is also done, first and foremost, aurally” (Green, 2002:206).

Green, (2002:73) found “there are a number of indications…that support the…supposition that…musicians…who have acquired their practical skills primarily through aural learning practices have very ‘good ears’”. Green adds, “Although their aural abilities are not necessarily any better than those of classical musicians, they are likely to be better sooner and, moreover, to be possessed by the vast majority of the players involved, rather than the few (Green, 2002:195). Green found that these well developed tonal and rhythmic understanding skills “are not only related to the development of performance skills but also form fundamental building blocks in compositional skills” (Green, 2002:75).

Conclusion

This chapter outlined strong parallels between music and language. This enabled an explanation of numerous claims that many trained musicians may lack the ability to think in sound. This form of music cognition is known as audiation and a specific kind of audiation is tonal understanding. Numerous sources suggested that audiation, and specifically tonal understanding, is fundamentally essential for authentic musical literacy: the ability to read and write and play music with understanding. Also presented were numerous claims that many formally trained musicians may have limited tonal understanding. Rather they may be left musically illiterate: dependent on kinaesthetic or other kinds of non-musical representations for performance and learning. This may limit their ability for spontaneous musical expression and composition. Some research has suggested that some informal approaches to acquiring music performance expertise may be more effective for developing tonal understanding skills.
The preceding discussion has identified several key areas of interest and raises key questions:

- Are the claims in the literature of limited audiation development in formal music training correct?
- To what extent are formally trained musicians musically literate, able to understand the music they play?
- Does musical training develop genuine aural representations or are musicians restricted to non-musical representations for performance?
- Are there differences in audiation between types of musicians?
- To what extent is audiation developed in the music learning population?
- What training or background factors might be associated with audiation development?

The core problem identified in the chapter was a general lack of knowledge about these important issues. The chapter proposed that the extent and significance of the problem may be in part obscured because it is possible to play a musical instrument by using non-audiation cues, such as notation. Therefore, the following chapter will review the literature for further evidence of a lack of information, and to examine a potential need to provide some empirical evidence on this issue.
CHAPTER 3: PREVIOUS RESEARCH IN AUDIATION

The core problem identified in the previous chapter was a potential lack of information about an important facet of music performance expertise: audiation, and specifically tonal understanding. The main aim of this chapter is to review pertinent literature that may provide further evidence for the numerous claims outlined previously and to identify any potential gaps in the knowledge of audiation in music performance expertise.

The chapter examines in more detail what audiation is, and how it relates to other memory processes. This information is intended to provide a framework for the potential design of this study. The chapter reviews numerous previous studies of audiation in order to examine how other research may have addressed the issues identified above. Many of the claims raised above imply a link between audiation development and musical training and therefore literature pertinent to this will be reviewed.

The previous chapter suggested that the issues may be obscured partly because of a widespread assumption that music performance expertise is based in notation and learning to reproduce pre-composed works. Therefore this chapter begins by outlining the extent of that assumption.

Recitation Bias

What evidence exists for the claims about audiation in musicians? The study and measurement of music performance expertise in general is considered a complex problem and there is a continuing lack of consensus on how best to do it. It has been described as one of the biggest challenges facing researchers (Law & Zentner, 2012:2) and educators (Green, 2002:209). A large part of the challenge lies in the difficulty in defining not only music but expertise. This has led to the observation that most research into music performance expertise fails to address this problem of definition (Sloboda, 2005:243). “What we have, instead, is a varied collection of empirical studies on single aspects of what some musicians do” (Sloboda, 2005:243). What most musicians do, in most research studies, is learn and recite Western classical music.

The assumption that the recitation of music from notation is synonymous with music performance expertise is pervasive and is evident in many areas of research, not only music education. A chapter on neuroscience and music begins: “Playing an instrument requires the ability to read musical notation and to translate it…” (Schlaug & Banger, 2007). The recitation assumption is also evident in the widespread use of the word “music” as a substitute word for “notation” even within music psychology literature: “the ability to read music [sic] is...an irreplaceable asset” to any musician (Sloboda, 2005:3). These views may not be shared by musicians in most of India, Asia, Africa and the Middle East who function mainly without notation, as do most traditional and folk musicians around the world, as well as most pop, rock, jazz, reggae and blues musicians and so on.
Because music recitation from notation has become the dominant approach to formal music training in most parts of the Western world, recitation has become the focus of “the bulk of research currently available” (Parncutt & McPherson, 2002:13).

In Chapter 2, the fundamental importance of audiation has been acknowledged by many researchers, pedagogues and musicians. As the claims above suggest, however, it is possible to recite music without the need for audiation. It is also possible to create improvisations and compositions without the need for audiation. Perhaps because of this, there appears to be a limited interest in research into the role of audiation in music performance expertise.

**Music Psychology Research**

Given the perceived fundamental role of audiation in music performance expertise, the absence of references to it in most music psychology literature seems particularly noteworthy. In one of the few books dealing with musical imagery, Godøy and Jørgensen (2001.ix) reviewed the literature “from antiquity to the present” and found little material dealing with mental images of musical sound. Schneider and Godoy, (2001:22) concluded that “one of the most crucial aspects of musical imagery”—the ability to think in musical sounds—”seems to be one of the least studied”. Schneider and Godoy, (2001:20) reported on a rare study into musical imagery in musicians (Kochmann, 1923) and noted that few experimental studies of musical imagery were published in subsequent decades until the 1980s (Weber & Brown, 1986).

In music composition expertise, the fundamental role of audiation has been acknowledged by many researchers, pedagogues and musicians. Yet information about audiation in the composition process appears largely neglected in the research literature. Sloboda (1988:103) found “composition is the least studied and least well understood of musical processes, and...there is no substantial psychological literature to review”. A quarter of a century later, Hubbard (2010:316) confirmed: “the state of the psychological literature on musical composition has not changed significantly since Sloboda’s (1988) assessment...and the empirical literature on the use of auditory imagery in musical composition is almost nonexistent (see also Mountain, 2001)”. This paucity of information on audiation may be related to the late development of the study of auditory imagery in general, which only became an independent discipline late last century (Klonoski, 2000).

A review of several major books on the psychology of music performance shows that the cognitive skill of audiation is of limited research interest. The recitation assumption in the music psychology literature appears to have created a focus on other aspects such as sight-reading and motor skills. (The book titles are included below to convey their intended focus).
Exploring The Musical Mind: Cognition, Emotion, Ability, Function (Sloboda, 2005) devotes the first three chapters to exploring the psychology of music reading, experimental studies of music reading and the uses of space in music notation. A section on acquiring musical skill returns to a discussion of sight reading. In The Musical Mind: The Cognitive Science Of Music” (Sloboda, 1988) a chapter on music performance discusses eye movements in reading, errors in reading, expressive aspects of sight performance, motor programming, and rehearsal. Memorization is described as “the ability to encode music in terms of familiar groupings and structures” (Sloboda, 1988:95). This is followed by a discussion of “finger technique” (96). The absence of discussion of audiation here is particularly notable given that the book begins by marvelling at Mozart’s prodigious audiation skills.

Gabrielsson's (1999) Psychology of Music Performance refers to hundreds of articles and studies on topics including: motor skills, extraneous movements, expressive movements, vibrato, timing, dynamics, structure, medical problems, hearing impairment and stress factors. Areas considered pertinent to the study of improvisation include physiology, neuropsychology, motor control, intuition, artificial intelligence, oral tradition and folklore, and historical and ethnomusicological surveys (Gabrielsson, 1999:513). With the exception of several references to “playing by heart” (this concept is not elaborated), studies into audiation are absent. There is a brief reference to the German music pedagogue Leimer, who emphasized the importance of being able to “hear the music [of the score] with one’s ‘inner ear’”, although the concept of inner ear is not discussed (Gabrielsson, 1999:505).

The Science and Psychology of Music Performance (Parncutt & McPherson, 2002) is primarily concerned with the science and psychology of music recitation. This is because the authors “realized that it would be impossible to cover all important aspects of music performance” (13). It contains limited references to audiation, and its development or role in music performance expertise.


Music Education Research
Although some kind of audiation training exists in most formal education curricula, it may suggest something of a neglect in this area that there appears to be an absence of published investigations of aural skills assessment in general (Karpinski, 2000:104), a rare exception being an exploratory study on scoring methods for melodic dictation by Gillespie (2001).
Tonal understanding also appears to be largely absent from most major music education research books which instead emphasize research into reading, technical, motor and theoretical skills. *The Handbook of Music Teaching and Learning* (Colwell & Richardson, 2002) is one thousand pages of teaching and learning mainly music recitation, although two chapters discuss improvisation. There are passing references to audiation and auditory skills.

*The Handbook of Research on Music Learning: Volume 2: Applications* (Colwell & Webster, 2011) contains chapters on listening to music; reading skills; movement; self regulation; school singing; special education and early childhood learning. *The Oxford Handbook of Music Education* (McPherson & Welch, 2012) is in two volumes of over 100 chapters, none of which are dedicated to audiation or its acquisition. *Music in our lives: rethinking musical ability, development, and identity* (McPherson, Davidson, & Faulkner, 2012), focuses on recitation ability, phrased here as “Western musical learning contexts” (1).

**Practice Research**

The bias towards the recitation model is particularly notable in the research into the role of practice in the acquisition of music performance expertise. Most research into instrumental music practice has occurred in the last few decades and the focus has been “almost exclusively” on the recitation practices of classical music by individuals (Jorgensen & Hallam, 2009:265). In many of these investigations, musical expertise is assumed to be predicated on overlearning sequences of prescribed motor action sequences derived from the visual cues of notation. Studies may involve, for example, observing pianists learning to recite a three-bar passage from a classical concerto (Duke, Simmons, & Cash, 2009), or learning a nine-note sequence on a piano keyboard (Simmons, 2012). The seminal study into the role of practice in the acquisition of music performance expertise (Ericsson, Krampe, & Tesch-Romer, 1993) was founded on the recitation model using classical musicians. Audiation skills are absent from this and most similar research.

**Previous Studies Of Audiation**

Attempts to measure musical aural skills began in 1883 with a series of simple tests by Carl Stumpf designed to help teachers to select potential music students. Since then many different tests have been developed, designed to test for a variety of musical aural abilities in people of various ages. In 1919, the first battery of music aptitude tests was published: the *Seashore Measures of Musical Talent* (Seashore, 1919). This work is seen as the seminal influence on subsequent musical aural tests produced throughout the twentieth century (Serafine, 1988).

From the 1920s to the 1960s a large number of musical tests were developed (See appendix 1). These tests were designed to measure skills in three broad categories: musical aptitude (talent or
potential); musical achievement (actual skills such as aural skills, or reading and technical skills); musical knowledge (theory or history and so on) (Murphy, 1999).

During the 1960s three tests had a very strong influence on subsequent music psychology research and remain the standard for tests of this type (Serafine, 1988:10). They were Gordon’s test of music aptitude, Colwell’s test of musical achievement, Bentley’s test of musical ability.

As these names suggest, a variety of terms are used in music aural ability research such as musical aptitude or potential, and musical achievement, attainment, ability or competence. Other terms may include musicality and musical intelligence. Often the terms are used interchangeably and may overlap, and there is no single agreed definition for these terms (Hallam, 2006).

In reference to psychometric aural tests however, several authors emphasize a strong distinction between tests that aim to measure musical aptitude, and tests that aim to measure musical achievement. Gordon (2007) stressed that the two things were not the same, and that a test could be designed to test exclusively for one or the other. To distinguish aptitude from achievement Gordon used the analogy of comparing general intelligence with academic achievement. Where intelligence is the potential to learn, academic achievement indicates what has been learned. For Gordon (2007), musical aptitude refers to the potential to learn to audiate, whereas achievement refers to audiation skill that has been learned.

There is, however, continuing disagreement around this distinction. Shuter-Dyson and Gabriel (1981:391) suggest that “to some extent”, a test of audiation achievement will naturally measure aptitude, and vice versa. Cooley and Lohnes (1976) suggested that the distinction between achievement, ability, and aptitude is a purely functional one. Bond (1989) reviewed measures of achievement, ability and aptitude and found support for Cooley and Lohnes’ view:

If a test is used as an indication of past instruction and experience, it is an achievement test. If it is used as a measure of current competence, it is an ability test. If it is used to predict or forecast future performance, it is an aptitude test. Yesterday’s achievement is today’s ability and tomorrow’s aptitude. (Bond, 1989)

Despite questions surrounding musical test research, there appears to be some consensus throughout the literature that audiation can be developed through appropriate training.

**Audiation And Musical Working Memory**

The basic cognitive processes involved in audiation have not so far been described in detail and there is still substantial debate about the concept of imagery (Holahan & Saunders, 1997:163). But audiation is presumed to occur via established neural pathways subserving “auditory processing, pattern representation, and decision-making” (Holahan & Saunders, 1997:163).
CHAPTER 3: PREVIOUS RESEARCH IN AUDIATION

The types and stages of audiation are numerous and range from simply listening to music to creating and improvising music in performance (Gordon, 2007:6). Of the many types and stages of audiation, all are based on the common principle of “concentrating on one set of musical sounds while at the same time attending to or performing one or more sets of other musical sounds” (Gordon, 2007:6). The process of holding information in mind while manipulating it, or attending to other information, is the function of working memory. This may suggest an important role of working memory in audiation.

References to working memory date from the 1960s and numerous models have been proposed (see Miyake & Shah, 1999 for an overview). One of the most influential models was introduced by Baddeley and Hitch (1974) and continues to generate large amounts of research (Postle, 2006). In this model, working memory refers to a brain system that provides temporary storage and manipulation of information used for higher order cognitive processing activities such as reasoning, learning and language comprehension (LaVoie & Cobia, 2007). Working memory is considered “fundamental and vital” to many higher order mental tasks including logical problem solving (Klingberg, 2009:33). It is also essential in control of attention (Klingberg, 2009:39). Because of its role as facilitator of higher order cognitive tasks, working memory has been described as the “workhorse of cognition” (LaVoie & Cobia, 2007).

The working memory system is thought to have two main subsystems, visual and auditory, coordinated by a third system: the central executive (Baddeley, 1986). The visual system—the visuo-spatial sketch-pad—is a short-term store for visual information, such as when manipulating chess moves in imagination. The auditory system—the phonological loop—is a short term store for verbal information, such as when holding a phone number in mind. One of the key functions of the phonological loop is thought to be language processing. It enables holding together the different parts of a sentence over time in order to understand it (Klingberg, 2009:87).

Audiation also involves a process of recognizing heard objects that unfold over time. Audiation has been described as the cognitive ability to “perceive, retain, compare, and synthesize tonal patterns and rhythm patterns as music…and reproduce and create tonal patterns and rhythm patterns as music (Holahan & Saunders, 1997:163). Patterns of tones rather than individual pitches enable audiation (Gordon, 2007:102).

To perceive patterns as objects we hold heard musical information in mind while listening to the successive parts of the pattern (Schneider & Godoy, 2001:12). Identifying musical sounds such as recalling a tonal pattern requires processing information held in short-term memory with structures stored in long-term memory. This “would seem to strongly support the model of working memory. As music is heard, the listener would attempt to place the information in some kind of organizational framework” (Berz, 1995:357).
Some authors have suggested that the phonological loop for memory of speech sounds may be analogous to working memory for pitch (Marin & Perry, 1999). The working memory model has been used successfully to explain results of several short-term memory studies that compared verbal and musical stimuli (Williamson, Baddeley, & Hitch, 2010). One study investigated whether the phonological loop of working memory might also handle musical stimuli and results suggested “a degree of overlap in the processing of musical and verbal sounds in short-term memory” (Williamson et al., 2010:172).

Berz (1995:357) however, found that Baddeley's model did not seem to fully account for music processing and that “the existence of a separate loop seems more justified”. He proposed an alternative model involving an additional loop dedicated to music processing. Schulze and Koelsch (2012) found partly differing neural networks underlying verbal and tonal working memory in musicians and suggested this could imply the existence of a separate tonal musical loop. Ockelford (2007) used evidence from a musical savant to also propose the existence of a separate “music module” in working memory. Berz (1995:357) proposed that the musical component of working memory would have a control process based on “inner speech, in this case, a musical inner speech” and “this might follow Gordon's (1988) definition of audiation”.

Authors have now begun using the term “musical working memory” (Royal, 1999). Musical working memory is thought to enable the sense of continuity of heard music, storage and processing of just-past stimulus patterns, and comparison of musical patterns (Royal, 1999:137). Musical working memory has been implicated in every single study on melody or pitch-progression perception, (Royal, 1999:137), and in many melodic perception studies, the contents of working memory “are taken as the dependent variable, the measure of how completely or accurately a stimulus has been perceived (Berz, 1995; Marvin, 1995)” (Royal, 1999). Audiation, and specifically audiation of musical patterns, appears to be strongly linked to musical working memory.

**Chunking**

One of the defining characteristics of working memory is its limited storage capacity. Only small amounts of information can be kept in working memory and normally only for a few seconds (Klingberg, 2009). The amount of storage space in working memory can be increased however, by grouping information into units or “chunks” (Miller, 1956). The letters I-F-B, for example, may count for three “bits” of information. But when rearranged as FBI they may count as one item, but only to someone with pre-existing background knowledge of the significance of that acronym. Grouping information into meaningful chunks can be applied to “anything” (Willingham, 2009:41).

Studies into various kinds of expertise, (card games, board games, electronics) have shown that both experts and beginners are constrained by the same limitations on working memory
storage. The important difference is that for experts “it is the chunk size that is larger” (Feltovich, Prietula, & Ericsson, 2006:50). Experts are more efficient than novices at using background knowledge to organize material into meaningful chunks.

**Training And Musical Working Memory**

Although there is only a limited amount of research on working memory capacity specific to music (Berz, 1995:354) it has been suggested that musical working memory capacity can be improved with training because such training improves the ability to chunk information (Berz, 1995:361). Chunking increases a musician’s ability to hear and understand music. Expert musicians can recognize and understand heard musical information and group it into scales, chords, sequences and patterns. This allows them to encode music in meaningful chunks and greatly reduce the number of “bits” to be remembered, freeing up critically important space in musical working memory (Karpinski, 2000:73). “As musical understanding increases, so does musical memory” (Karpinski, 2000:73).

Developing this chunking ability in musicians is one of the main goals of aural training (Karpinski, 2000: 77). Such training requires developing pattern audiation as well as musical understanding. Gordon, (2007:104) suggested that the ability to audiate differences among patterns develops with the practice of listening and copying. There is a strong inference running through the literature that musical working memory is amenable to training and may be enhanced through some musical activities.

**Edwin Gordon**

Gordon (1998:68) spent several decades measuring audiation in thousands of students in many parts of the world. Although Gordon’s focus was on measuring audiation, often the emphasis in the research was to try to establish children’s musical aptitude. Much of Gordon’s research centered around measuring listeners’ ability to recognize and compare various kinds of tonal and rhythmic patterns. To describe the key role of tonal pattern audiation in music performance expertise Gordon used analogies with language:

> When students learn to audiate and perform music…it is no different from the process we go through as we learn to think in words and communicate through speech. Just as words are the smallest units of meaning in language…tonal patterns…are the smallest units of meaning in music and are assimilated first. Learning to listen to and identify patterns in music prepares students to listen to and perform extensive music literature with understanding. (Gordon, 2007:ix)
CHAPTER 3: PREVIOUS RESEARCH IN AUDIATION

Gordon’s Musical Aptitude Profile (MAP) (Gordon, 1965) was designed to evaluate music aptitude, or potential. It has three sections: tonal imagery; rhythm imagery; musical sensitivity. Gordon (1998:94) explained that the word “imagery” in these test names actually stands for “audiation”, a term he coined only later.

During the 1970s, Gordon (1998:68) tested audiation in more than 10,000 children. Large groups of students of various ages heard recorded pairs of tonal and rhythmic patterns in major and minor tonality. They were asked to identify whether each pair was the same or different. Gordon’s aim was to identify the comparative difficulty of audiating rhythmic patterns and patterns. From this research Gordon developed a taxonomy of musical patterns which formed the basis for several tests of audiation.

The Primary Measures of Music Audiation (PMMA) (Gordon, 1979b), for children ages 5-8, is a same-different test using tonal and rhythmic patterns of 2-5 notes, mainly in major tonality and in the same key and tempo. The Intermediate Measures of Music Audiation (Gordon, 1979a) designed for children aged 6-9 years, is a same-different test using three-note patterns, mainly in minor tonality, at same tempo and same key (Gordon, 1998:73). The Advanced Measures of Music Audiation (AMMA) (Gordon, 1989) aimed to measure audiation in secondary and tertiary level students, professional musicians and non-musicians (Gordon, 1989). It is a same-different test using a variety of pairs of rhythmic and tonal patterns. The Iowa Tests of Music Literacy (ITML) (Gordon, 1991b) was designed to test not musical aptitude but achievement. It is a multi-level battery designed to measure tonal and rhythmic audiation in children up to Year 12 of secondary school (Gordon, 1998:159).

Gordon’s tests have been used in a variety of studies, including numerous music research studies of young children in many different countries. The AMMA was used in a factor analysis study of the audiation abilities of 5,336 undergraduate and graduate students, music major and non-major from 54 tertiary institutions in the United States and Canada (Gordon, 1991a). A smaller version of that study was replicated in Bremen, Germany, with 129 graduate and undergraduate students music and non-music majors. The aim was to establish if the AMMA test remained consistent for tertiary students of a European country (Gordon, 1991a:45). The ITML was administered to almost 20,000 students in the United States in 1970. After revision in 1993 it was administered to a further 6,500 students. Results were similar across both groups (Gordon, 1998:161).

Gordon’s tests have been used in a variety of studies by other researchers. Schleuter and Schleuter (1989) used Gordon’s PMMA to pre- and post-test the audiation skills of 200 pre-school to third-grade children to evaluate the effect of school music training, mainly on rhythmic responses. Holahan and Thomson (1981) used Gordon’s PMMA to test 514 English schoolchildren, aged five to
eight. They compared their results with similar results from the United States and determined that the PMMA was sufficiently reliable and a suitable measure of aptitude for English children. Holahan and Saunders (1997) used three-tone melodic patterns based on Gordon’s taxonomy to test primary school children. Their study focused on response times and whether tests of audiation and music aptitude could exhibit practice-effects. Holahan, Saunders and Goldberg (2000) used pairs of tonal patterns taken from Gordon’s (1978) taxonomy of music patterns to study audiation in 48 tertiary students, 24 music majors and 24 non-music majors as well as 38 primary school students. The study focused on response times and an analysis of the effect of melodic pattern structure on response times.

**Audiation And Working Memory Capacity**

In many audiation studies, the discussion of results tend to imply a causal relationship between musical training and audiation skill. The implication is that audiation skill develops with training. Correlation, however, does not imply causation, and it is possible that audiation skills are pre-existing, and that this influences a musician’s learning pathway. The possibility that audiation exists outside of musical training has been suggested by some studies that have shown a link between audiation and innate working memory capacity.

Note that in the literature, the terms short term memory and working memory are often used interchangeably and there is ongoing debate about the relationship between them. It is thought that short-term memory involves a passive store. In contrast, working memory tasks “require some kind of additional manipulation, contain some form of distraction, or demand a degree of simultaneous performance” (Klingberg, 2009:43).

Results of a study by Geake (1999) using 80 school children, including several gifted music students, suggested that success on Gordon’s MAP may be strongly related to short-term memory capacity, that is, non-musical information processing ability. Geake conjectured that because of this, the MAP may not provide as complete an assessment of musical aptitude as intended.

Others studies support that the ability to score highly on a same-different task is significantly related to short-term memory. Holahan (2000) investigated the development of tonal audiation skills. Twenty-four tertiary musicians, 24 tertiary non-musicians, and 38 first-grade children heard pairs of three-tone same-different patterns derived from Gordon’s (1978) taxonomy. Results indicated a basic role played by working memory in same-different tests and tonal audiation, particularly in musical novices (Holahan et al., 2000:175).

Zenatti (1985) also found short term memory capacity to be a significant factor in results on same-different tests. She summarized findings from several of her investigations into the role of memory in musical tests (mainly using same-different patterns). Age was found to be a significant
factor in the development of capacities for discriminating melody and harmony in tests, which Zenatti accounted for by a progressive increase in working memory capacity (Zenatti, 1985:402).

Ruthsatz, Hanus and Tiu (2002) investigated the relationship between working memory and results on Gordon’s Advanced Measures of Music Audiation (AMMA). 57 tertiary music students were compared with 63 tertiary non-music majors. In addition to the AMMA, a working memory test was administered. Results for musical novices showed a significant relationship between working memory and music audiation \((r = .57, P < .01)\). Tertiary music students did not yield a similar correlation \((r = .04, P > .05)\) suggesting that audiation ability in novice musicians may be highly dependent on innate working memory capacity. Again, the researchers believe that musical training can enhance this ability.

Reports of exceptional memories are found consistently in case studies of musical prodigies and musical savants. Ruthsatz and Detterman (2003) used Gordon’s Intermediate Measures of Music Audiation to test the audiation abilities of a six-year-old musical prodigy. The prodigy achieved a composite score at the 98% level for musically talented children. Other testing of the prodigy revealed an extraordinary memory. The authors suggest that their results call into question Gardner’s (1983) theory of multiple intelligence, in which he described audiation as the core of “musical intelligence”. They speculate that Gardner's musical intelligence may be “nothing more than an exceptional short-term memory transferred into the musical domain” (Joanne Ruthsatz & Detterman, 2003:517). Berz (1995:362) also suggests that individual differences in results on same-different music tests, may “represent not talent or musical intelligence but ability, reflecting differences in working memory capacity”.

Wallentin, Nielsen, Friis-Olivarius, Vuust and Vuust (2010) developed a same-different pattern test: the Musical Ear Test (MET). Part of their study tested whether achievement on the MET was related to other working memory tasks. They found that professional musicians had significantly greater working memory capacity than non-musicians. The authors attributed a causal role of musical training to audiation development, suggesting that audiation “will develop as a consequence of musical training” (Wallentin et al., 2010).

Whether or not there is a causal link between types of musical training or practices and audiation development is a complex question. Certainly, there appears to be a significant relationship between achievement in audiation tests, particularly same-different tests, and musical working memory.

Some studies compare multiple pre-existing tests, or parts thereof. Young (1976) conducted a longitudinal study combining parts of Gordon’s MAP and ITML, the Bentley Measures of Musical Abilities and the Colwell Music Achievement Tested with 768 sixth grade students in
several American states. The MAP was found to be the most efficient test of aptitude, and the ITML possessed the highest validity for measuring music achievement.

Some studies use pre-existing tests or parts of them in combination with ad hoc tests constructed specifically for the study. Schleuter (1993) used Gordon’s AMMA with tertiary music majors and examined the results in relation to sight-singing, melodic transcription and SAT scores.

Mohatt (1971) used all six levels of the ITML to study the music abilities of 164 high school students. He then evaluated the students with his own tests which included recognition of modes and metre as well as some sight reading tasks. Results on these tests were correlated with the ITML and the majority of validity coefficients were .40 and higher.

Brown (1990) used parts of the Colwell Music Achievement Test to investigate aural abilities of tertiary students, music- and non-music majors. He also tested for pitch discrimination, notation reading, piano skills and aural acuity. The focus of the study was to pilot a system of tuition in playing by ear.

Researchers may conduct studies using their own tests based on aspects of published tests. Mills (1985:141) developed a “Pitch Test” which was closely related to the “pitch discrimination” subtest of Bentley’s (1966) Measures of Musical Abilities”. Two tones were presented consecutively, and participants made a judgment concerning the relative pitch of the tones. Mills (1985) used this pitch test as well as a “Pulse Test” to test the “musical ability” of 1715 schoolchildren in the age range 6-16. Results suggested that the ability to audiate upward and downward intervals is age dependent.

**Tertiary Entrance Tests**

Tertiary entrance tests are aimed at evaluating aural and theory skills of incoming students at tertiary music institutions. The Aliferis College Entrance Test was administered in Poland at 104 Primary Schools, 34 secondary schools and seven music academies (Aliferis, 1983). One aim of the study was to demonstrate that the Aliferis test measured both music aptitude and achievement. The study found that music achievement of Polish music students age 15 or more is higher than USA tertiary entering music major students. Polish researchers subsequently compared the results of the Aliferis test with those of Drake (1957) and Wing (1962) and found low correlations (Aliferis, 1983).

Many tertiary music institutions develop their own aural test batteries in order to evaluate aural skills of incoming students. The Ohio State University Entrance Battery (OSU) has several ear-training sections which test pitch and rhythm discrimination (Arenson, 1983). Arenson (1983) used the OSU and parts of Colwell’s Music Achievement Test to test 192 first-year tertiary music students at the University of Delaware. The aim was to assess the predictive ability of the OSU
tests. Data from the two tests were compared and suggested that results on the OSU were a good predictor of grades in first year aural and theory courses.

Pembrook and Taylor (1986) developed their Melodic Discrimination Test (MDT) to test 351 applicants to the Florida State University School of Music. The test lasted less than half an hour, and focused on melodic rather than rhythmic material. Participants were asked to discriminate melodies, intervals, tonal alterations in melodies, and pitch differences in pairs of tones. Results were compared with background information on years and type of study musical experience. They found that musical experience (such as time spent performing in ensembles) led to significantly better performance on the MDT (Pembrook & Taylor, 1986:19).

**Australian Test For Advanced Music Studies**

The Australian Test for Advanced Music Studies (ATAMS) (Bridges, 1978) was developed in response to a perceived lack of suitable tests to assess the aural abilities of incoming students to tertiary music institutions in Australia (Bryce, ND). Comprised of three books, it was designed to measure among other things, aural imagery and musical memory. A review of aural tests found ATAMS to be similar but superior to, the Aliferis (Phelps, 1978). ATAMS has been used widely throughout Australia, for example in a study by Bridges (1978) with 740 first year tertiary music students.

Weidenbach (1994) used Book I of ATAMS to test Australian tertiary students with diverse musical backgrounds. In Poland, ATAMS was used with 3000 students and results indicated that ATAMS measured relevant music abilities and predicted success in music studies (Bryce, ND). Jankowski and Miklaszewski (2001) reported on a study by Meyer-Borysewicz (1995) which used the ATAMS (Book II) to compare scores between Australian and Polish applicants to tertiary music institutions, and found an advantage to the Polish students. ATAMS was also found useful by Manturzewska (1992) to investigate musical giftedness in Polish musicians.

**Musical Training And Audiation**

The relationship between musical training and audiation is the basis of many studies that compare “trained musicians” and “non-musicians” (that is, people without musical training). Several of these comparison studies support claims in the literature that formal musical training often fails to develop important audiation skills.

Madsen and Madsen (2002) investigated melodic perception in different levels of age and musical training. 62 sixth-grade students, 58 eighth-grade students, 60 young adults and 60 trained musicians listened to 16 unfamiliar melodies, each followed by a further eight melodies. The aim was to test participants’ ability to perceive a target melody when very similar melodies are
interpolated. Results suggested that “the many years of training completed by musicians does not seem to give them a decided advantage” in remembering and discriminating melodies (2002:127).

Schellenberg and Moore (1985) tested for melody retention by comparing 57 music-majors and 57 non-musicians. Participants heard short folk melodies in various configurations and were asked to identify whether they were same or different. Although the non-musicians made more errors, the pattern of errors was not significantly different to the music majors.

Sloboda (2005:104) asked participants to sing back heard melodies. Recordings of short, unfamiliar folk melodies were used to test for melodic recall in tertiary level musicians and nonmusicians. Despite their training, the formally trained musicians recalled less than half of the original melody (Sloboda, 2005:105). Results showed that average scores were low in both musicians and non-musicians, and that both groups did not retain a large amount of the melodic sequences of the heard melody (Sloboda, 2005:105).

The results of these studies are interesting because they support claims in the literature that musical training may not confer advantages in audiation skills compared with no training. But it is particularly important to note that in almost all of these kinds of studies, and in most previous studies into audiation, the type of musical training of participants is usually never discussed.

Many studies in a wide range of fields compare so-called musicians with non-musicians. Throughout a wide range of literature there is an overarching tacit assumption that musical training is synonymous with learning to recite classical music. Few studies focus on potential differences in audiation competencies that may exist due to different types of musical practices: for example listening-copying musicianship.

Some acknowledge this limitation. McPherson (1995:158) suggested that because all participants in his study were trained in music reciting, “any conclusions that can be drawn need to be treated cautiously until research replicates and extends the findings using other groups of instrumentalists”.

Other researchers have noted the bias towards music recitation in study participants. Lehman and Gruber (2006:466) note a paucity of research into music expertise outside the recitation model, describing studies into other genres as “rare”.

McPherson (1995:143) found that despite the widely acknowledged importance of aural musicianship, it had been the focus of few scientific studies. Woody and Lehmann, (2010:103) confirmed that aural musicianship has received “little attention” in music psychology or music education research and a qualitative study into it by Johansson (2004) is described as a “a rare example”.

Of particular relevance to this present study is the absence of experimental studies on the relationship between aural musicianship and results on same-different pattern tests (Lehmann & Ericsson, 1997:44).
**Audiation And Type Of Musical Training**

Recently there has been a growing interest in comparing types of musical training practices. Baker and Green (2013) conducted a case-control experiment to test the relationship between type of musical training and audiation development. Thirty-two instrumental music students aged 10 to 14 years participated. Half of these students received traditional recitation-based training while the experimental group learned aurally. All participants were subsequently tested using ABRSM designed aural tests. The aural musicianship group performed better in every criterion. This appears to support the notion that different music training approaches may lead to different audiation competencies.

Woody and Lehmann (2010) compared aural musicianship skills of 24 tertiary music students, half of whom were primarily recitation musicians and the others had some experience with aural musicianship practices such as playing by ear and improvising. Participants heard melodies and were asked to perform them, either by singing or playing back. The researchers tracked the number of times through the listen-then-perform cycle that were needed for accurate performance. The aural musicianship group required fewer trials than the recitation musicians.

Woody and Lehmann (2010) also acknowledged that their study had only “scratched the surface” of understanding how aural music practices contribute to building musicians’ “ears” and that there was a need for further research involving greater numbers of musicians and alternative research paradigms (Woody & Lehmann, 2010:113). Comments by the authors suggest that pattern audiation played an important part in the superior results of the aural musicians. Woody and Lehmann (2010:112) note:

> Both of the study’s melodies make heavy use of patterns… practically prescribing a “patterned listening” approach…The [aural] musicians appeared better able to exploit this in the performance task; they tended to describe the melodies as predictable or typical, whereas the formal musicians largely expressed the opposite. The formal musicians also more frequently used an interval-based or scale degree-based approach in their instrument production.

The aural musicians’ description of the melodies as “predictable” supports Gordon’s model of audiation in which the advanced stages include the ability to predict musical patterns (Gordon, 2007).

Tervaniemi, Rytkönen, Schröger, Ilmoniemi & Näätänen (2001) compared pattern audiation skills of musicians from different learning backgrounds: seven non-musicians, five classical musicians and eight popular musicians. Participants heard short melodic patterns and brain responses were recorded using event-related potential (ERP) recordings. Only the brains of the improvising musicians reacted to contour variations within temporally complex patterns. The aural
musicians brains exhibited faster and more accurate memory traces for the pitch contour of complex tonal patterns. This suggested that the ability to detect changes in highly complex auditory patterns may be facilitated by the type of musical expertise, namely, aural musicianship (Tervaniemi et al., 2001:295). Commenting on these results, Brattico and Tervaniemi found:

This suggests that the long-term practice of playing without a score, for example, during jazz improvisation, has plastically modified the neural circuits to improve performance and facilitate automatic extraction and recognition of musical patterns (an auditory skill that is assumed to represent a factor in improvisation…). (2006:311)

Based on the findings of the study by Tervaniemi et al. (2001), Seppänen et al. (2007) investigated whether differences in types of musical expertise affected audiation skills. They compared 13 popular musicians with 11 recitation musicians. Gordon’s AMMA was used to evaluate whether there were any inter-group differences in musical pattern discrimination. Additionally, participants heard short melodic patterns. Brain responses were recorded using event-related potential (ERP) recordings. Results indicated differences between the two groups in melodic contour and interval processing and perceptual learning. These differences in music processing facilities existed, the authors noted, despite that fact that all participants were musicians, with the same level of expertise in music, but in different genres, which suggested “the presence of distinct brain mechanisms dedicated to skills required by particular practice strategies” (Seppänen et al., 2007:244).

Summary
This information presented in this chapter can be summarized as follows:

- Melodic patterns, rather than individual pitches are the basis for audiation. Learning to listen to and identify melodic patterns is an important step in more complex musical understanding.
- Audiation involves listening to music while simultaneously comparing it with other musical sounds. This appears to implicate the musical working memory system.
- Numerous tests of audiation are based around same-different frameworks, where listeners hold one pattern in mind while comparing it with a subsequent one.
- A defining characteristic of working memory is limited storage space.
- Chunking increases the storage space of musical working memory.
- Some kinds of musical training may increase storage space and consequently audiation ability.
Conclusion

Two important conclusions form the basis for the present study. First, formally trained musicians may be lacking in audiation and tonal understanding skill. Second, some types of musical training may develop audiation skill more efficiently than others. The main aim of this chapter was to examine relevant literature on audiation and tonal understanding for evidence to support the perceived gap in knowledge proposed above. Following a review of the major music psychology literature, including books and journals, as well as the music education research, a picture emerged that supported the claims mentioned above of a general lack of information on the state of audiation and tonal understanding in Australian music students. Some of this gap in knowledge may be attributable to a bias in research towards the recitation model of music performance expertise.

Numerous studies in audiation were reviewed. Many of these were aimed at young children, and often to identify musical potential. A number of studies have suggested an association between audiation and musical working memory capacity. There is also emerging some association between audiation development and type of musical practices and training. Although some studies have examined potential differences in audiation related to musical training, many studies appear to be biased towards participants with training uniquely in music recitation.

Little information was found on the extent to which trained musicians understand heard tonal music. No studies were found that specifically surveyed tonal understanding and audiation skills in Australian music students. The fact that so few studies have been conducted which target tonal understanding among a range of types of musicians highlights the need for further research. Areas of research requiring attention include the following:

- The need to clarify the degree to which trained musicians have tonal understanding.
- The need to establish the degree to which trained musicians audiate melodic patterns.
- The need to establish the degree to which training is associated with audiation.
- The need to identify other variables which may impact on the development of audiation.
- The need to select valid and reliable measures of melodic pattern audiation and tonal understanding.

A study that included musicians from various musical backgrounds, and learning styles, has the potential to provide important information about the development of audiation in musicians. This information would potentially inform the teaching and learning of instrumental music performance expertise.

The following chapter examines some of the methods available to measure audiation and tonal understanding and reviews some of the issues and challenges in efforts to measure music performance expertise in general.
CHAPTER 4: PREVIOUS MEASUREMENT OF AUDIATION

The previous chapter identified gaps in the knowledge of audiation that would benefit from empirical evidence of these skills in musicians. The main aim of this chapter is to provide relevant background information on audiation measurement that will form the basis for the design of this study. The following section examines methods previous researchers have used to measure audiation and tonal understanding, and the suitability of tests for this study. The chapter begins by reviewing some of the challenges faced by researchers in trying to measure musical skills in general, and audiation in particular.

Validity: Internal Versus Ecological

Musical experiences are highly complex and significant aspects of musical experience defy precise measurement. Many researchers have identified the fundamental dilemma of trying to measure genuine musical experiences in controlled situations. Finding a balance between control over variables—internal validity—while maintaining some element of real-life musical experience—ecological validity—is seen as “one of the major difficulties” (Lipscomb, 1996:137) if not “the principal problem” (Sloboda, 1988:152) in music perception research. There is a perceived “fundamental incompatibility between two eminently desirable goals: experimental rigor on the one hand, and musical validity on the other” (Butler & Lochstampfor, 1993:14). Pratt (1998:1), observed a conflict between finding “identifiable measures of achievement and the study of an art which is often very subjective and defies precise measurement”.

Ecological validity requires methods that provide “a representative musical context for studying musical sound” (Lipscomb, 1996:137). Yet many studies “use test materials which are so impoverished that they do not really provide a context for musical perception at all” (Cook, 1994:67).

There has been a large amount of investigation of perception and memory for melodies in various areas. Some studies have examined the perception of intervals (Conner, 1970); the effect of melodic context on pitch recognition (Deutsch, 1982); how length of melody and position of a pitch within a melody affected memory retention (D. Williams, B, 1975); and how timbre changes in melodic sequences affect retention (Holly, 1980).

Lipscomb (1996:137) reviewed studies of melody perception and found that in an attempt to increase reliability, many researchers used methods that were reductionist such as using computer generated synthesized pitch sequences. The use of electronically generated tones lacking musical nuance is a widespread practice in tonal memory research (Bartlett, 1996:191). Many researchers question whether results obtained in “constrained, perhaps even artificial” (Hodges, 1996:v)
experiments using “vastly oversimplified ("beep boop") pitch sequences” (Lipscomb, 1996:137) can be generalized to the external world.

The question of type of audio stimuli is not merely an aesthetic one. Type of musical stimuli is an important variable that can influence how the brain processes sound. Real music, for example, is processed differently to MIDI-generated chord sequences (Edwards & Hodges, 2007:8).

Bartlett (1996:178) identifies the problematic nature of music cognition research that focuses on unmusical tasks. He makes a strong distinction between “tonal memory” tasks—that use unmusical isolated electronic tones—and “musical memory” tasks that use material with a musical structure that is played on actual music instruments. Bartlett (1996:178) noted that there are few musical memory tasks in the literature.

Sloboda (1988) suggested that most research does not satisfactorily deal with the problem of relating research finding to “normal music listening”. Rather, most research:

…evades this crucial issue by examining responses to very brief segments of music, made up of between two and twenty notes. Such segments hardly present listeners with the range of patterns and relationships which they must deal with in even the simplest short song. (Sloboda, 1988:152)

Another important variable that influences the way we process musical sound is the type of listening task: for example, “holistic listening versus discrete features detection” (Edwards & Hodges, 2007:8). Many aural tests involve the identification of isolated intervals. Tonal context, however, is an important factor in how listeners remember pitches (Karpinski, 2000:38). A “preponderance” of experimental evidence demonstrates that identifying isolated intervals out of any context has little connection to being able to identify them in a tonal context (Karpinski, 2000:52). Burns and Ward (1982:264, cited in Serafine, 1988:26) suggested that “the perception of isolated melodic musical intervals may have little to do with the perception of melody”. Serafine (1988:26) suggests that decades of research focusing on atomistic elements of music such as tones, intervals, and chords “have yielded almost no convincing theory about how complex music is constructed, perceived, and remembered”.

Lipscomb (1996:167) observed that “a majority of [music-cognition] studies continue to be overly reductionist in their methods, trading validity for reliability and control”. Butler and Lochstampfor (1993:15) question whether perhaps there must be “an unavoidable trade-off” between experimental rigor on the one hand, and musical realism…on the other”. They suggest that “as musicians we…would settle for somewhat looser experimental methodology, rather than conducting elegant studies that give reliable evidence about musical trivia” (Butler & Lochstampfor, 1993:15).
CHAPTER 4: PREVIOUS MEASUREMENT OF AUDIATION

Problems with Audiation Test Batteries

One major obstacle to measuring audiation ability is that it is not directly observable. Despite great advances in technology, there still exist “severe limitations” on the kinds of musical activities that can be measured effectively (Edwards & Hodges, 2007:14). Law and Zentner (2012:1) have noted “little interest” in development of an efficient and construct-validated test for measuring individual music aural skills. They note an absence in the last few decades of research into aural test batteries (Law & Zentner, 2012:13).

Various other problems have been identified with many of the psychometric music tests developed last century. Many of the test have been described as obsolete (Carson, 1998; Murphy, 1999). Some of the problems identified (Law & Zentner, 2012) include:

- Neglect of stimulus design and control
- Design flaws: uneven number or duration of stimuli within subtests, variations in answer formats across subtests, and insufficient control of response bias and guessing patterns
- Tenuous inference of validity and reliability, based on obsolete indicators of internal consistency, and insufficient description of validation procedures.
- Ambiguity in results on some subtests due to a conflation of skills being tested.
- Designed to test generic aptitude
- Inconsistencies between standard and comparison trials due to human variation, including slips in performance in recordings of test materials.
- Poor sound quality including distortion, due to limited recording techniques or degradation over time.
- Design aimed at measuring deficits rather than normal range of aural skills
- Intended for cochlear implant users

For these reasons, many test batteries developed last century are not used in music psychology research today (Law & Zentner, 2012:3).

Of the numerous psychometric tests developed last century, many appear to lean more towards experimental rigor and may exhibit some limitations of ecological validity. The Bentley Measures of Musical Abilities (Bentley, 1966) for example contains pitch perception tasks using intervals of less than a semitone. It also contains a chord analysis test using two-note chords. The Drake music tests (1957) require participants to remember intervals and three-note sequences. The Aliferis Music Achievement Tests (1954) uses intervals and four note patterns (Shuter-Dyson and Gabriel 1981:43).
Many of the tests do not require tonal understanding or any prior knowledge of music. Gordon's (1965) MAP for example included a “musical sensitivity” test where listeners compare interpretations of specially composed musical excerpts. Many tests like the MAP are aimed at small children and test for generic musical aptitude rather than achievement. Hubbard (2010:315) commented that because it is designed to measure musical aptitude, Gordon’s MAP has “so far…contributed little to an understanding of auditory imagery or musical imagery”. Other researchers have also found aptitude tests to be unsuitable as tests of audiation achievement (Law & Zentner, 2012). Many are no longer available, out of print or difficult to access.

**Australian Test for Advanced Music Studies**

The Australian Test for Advanced Music Studies (ATAMS) (Bridges, 1978), showed potential for this study. ATAMS was developed as an objective test of musical comprehension and aural abilities for use with students applying to study music at the tertiary level (Bridges, 1978). In a review of similar tests, it was rated as “undoubtedly the best and most up-to-date tests developed to measure the prior achievement of entering college music students” and better than the two Aliferis tests used at the time in the US for a similar purpose (Bryce, 2011). The entire test takes almost three hours to administer which is too long for this study. But it is divided into three sections. Book two tests reading ability and understanding of notation and Book three tests for atomistic elements such as pitch, interval and chord recognition both of which are outside the scope of this study.

Book one seemed most relevant for this study as it tests for aural perception and memory. This test requires no knowledge of notation or musical terminology and could be used for students at tertiary level who have had no prior musical tuition. It is a multiple choice test displaying some ecological validity by incorporating real pieces of music for the subtests. It takes 45 minutes to administer.

After informal piloting of this test with several musician colleagues it became immediately apparent that ATAMS would be unsuitable for use with this study. Many tasks were outside the aims of this study. There were numerous recognitions tasks, such as recognizing the number of times a melodic theme occurs, or type of instrument timbre, type of ethnic music, type of classical music genre, and recognition of themes and variations in atonal melodies and synthesized electronic music. Although these kinds of tasks clearly utilize types of audiation, they clearly did not target the tonal understanding and pattern audiation that are the focus of this study.

**Iowa Tests Of Music Literacy**

A further review of available tests suggested that Gordon’s (1970) Iowa Tests Of Music Literacy (ITML) was potentially suitable for the study. The ITML were designed to measure achievement (rather than aptitude) in tonal, rhythmic and notational audiation (Gordon, 1991b).
ITML has six levels, each sequentially more difficult, with level six being considered suitable for final year secondary school students. The level six tonal audiation listening test takes 10 minutes. The ITML seemed convenient because it could be administered to individuals or large groups, and did not require any notation skills. An added advantage was that the ITML also had thousands of standardized results from testing in the United States. This data had the potential to make a useful frame of reference for results from Australian students.

Informal piloting with myself and various musician colleagues revealed properties that rendered it of significantly limited potential for this study. In level six of the tonal listening section of the test, listeners hear brief passages of tonal music played on an organ. The entirety of the task is to nominate whether the passage is major or minor tonality. The task of audiating whether music was in major or minor tonality seemed to be very limited in scope compared with the large range of audiation stages and types that exist. Pilot testing confirmed this limitation, revealing large ceiling effects. This immediately indicated that the ITML might not capture the full range of audiation abilities in tertiary music students. Additionally there were problems with ecological validity. The music used for the items were created specifically for the test and seemed to lack musical interest or nuance. Another problem was audio quality. The test was developed in the late 1960s and the organ sound has become dated to modern ears. This sound when combined with the distortion that was present in the recordings gave the test an unsettling atmosphere. For these reasons the ITML did not appear to present an optimal test of audiation for the modern ears of tertiary music students.

**Ad Hoc Tests**

Many researchers prefer to develop ad hoc tests. Humphreys (1986) tested audiation abilities of 45 tertiary music students. Tasks included using chord symbols to harmonize notated and recorded melodies, and performing harmonic accompaniment to recorded melodies. Results suggested harmonic audiation was highly correlated with melodic echo-playing ability.

Many ad hoc tests use sing- or play-back methods. Participants listen to a music sequence and are asked to sing or play it back to the researcher. Kochmann (1923) asked males aged 10 to 17 to listen to sequences of ten-note, unfamiliar melodies. Participants were then distracted with other musical tasks before being asked to recall and sing the original heard melodies. Results varied substantially in extent and precision of recollection (Schneider & Godoy, 2001:19). Schneider and Godoy (2001:20) report that after Kochmann’s, very few studies specifically on music imagery were published until Weber and Brown (1986).

In the Weber and Brown study, participants heard simple sung melodies and were asked to designate the contour of the melody. One group was allowed to sing the melodies aloud while the other
was restricted to audiating it silently. Results did not show any marked difference between the two groups’ ability to remember simple melodies (Schneider & Godoy, 2001:20).

Williams (1975) also used sing-back to test 13 tertiary music students for short-term melody retention. Participants heard three-, five- and seven-pitch sequences and were asked to recall certain pitches from the sequences and to demonstrate by singing. There were 630 trials, and testing took place over three weeks.

Studies using playback methods, for example, could be said to require some level of musical understanding in order to translate heard sounds onto an instrument. One way of measuring tonal understanding in musicians would be to have them play back heard melodies on their instrument. Many studies have used play- or sing-back methods to investigate audiation skills. An important limitation, however, to this approach to measuring musical understanding is the problem of imitation.

There is a strong distinction in the literature between “musical understanding” and “imitation” also known as “memorization”. Musical memorization is the ability to repeat what has been heard (Karpinski, 2000). Several authors stress that it is possible to imitate a tune without understanding it (Gordon, 2007; Gruhn, 1997; Karpinski, 2000). To sing back a melody for example, it is not necessary to understand any theoretical elements of the music. Imitation also happens on an instrument when someone can “parrot” back a tune, and does not necessarily require an understanding.

In contrast to this, musical understanding requires comprehension of “relationships such as metric grouping, relative rhythmic proportions, and tonal function” (Karpinski, 2000:78). Therefore a person playing back a tune may not necessarily provide a certain indication of tonal understanding.

Tests of Improvisation and Playing by Ear

Gordon (1998:32) proposed that because audiation is not directly observable, the “most acceptable indirect criterion” to demonstrate audiation ability would be samples of musicians’ improvisation. Many people assume that for expert improvisors, their improvisations are a direct expression of their musical thought, in the way that speech is an expression of thought. But Gordon (1998:32) cautioned that “few persons in our society are able to improvise even at the most elementary level”. Despite Gordon’s pessimism, some have tried to measure audiation ability by evaluating improvisation and playing by ear.

McPherson, (1995) used his Test of the Ability to Improvise (TAI) to measure improvisation ability in music students. 101 high school clarinet and trumpet students (McPherson, 1993; 1995) and 157 primary school children (McPherson, 2005) were tested. These studies focused on the interplay between multiple musical skills including aural, visual and memorization skills. McPherson (1993:323), claimed to have clearly demonstrated that most students lacked an aural
understanding of the music they play, and attributed this to the failure of recitation training to develop this skill.

Tasks included improvising an “answering” phrase in response to a given “question” phrase; improvising with a given rhythmic pattern and a given motif; improvising over piano accompaniment and improvising freely. Judges rated the performances for instrumental fluency; musical syntax; creativity; musical quality (McPherson, 1995:149). McPherson (1995) also developed a Test of Ability to Play by Ear which required participants to play known tunes, as well as briefly presented unknown tunes, from memory and to transpose them. Judges were also used to assess these performances.

The issue of assessment of any kind of music performance ability is seen as challenging because of the difficulty of defining not only ability, but also music (Law & Zentner, 2012). Assessment of music performance has been described as the one of the most significant problems facing educators (Green, 2002). Attempts to measure musical creativity add to the complexity of the problem because there is no unambiguous definition of creativity. This makes it “extremely hard to isolate empirically” (Williamon, Thompson, Lisboa, & Wiffen, 2006:164). Kaufman and Baer (Kaufman & Baer, 2012:83) outline some of the problem:

Unless there is a clearly established standard or set of criteria, determining how well a product or idea meets the (generally ill-defined) constraints of the task or problem is far from simple. Such criteria are rare; the very nature of creativity is such that it is expected to include the unexpected…Not everyone will agree with every expert opinion. (Kaufman & Baer, 2012:83) (see alsoElkins, 2001; Montague, 2007; Pinker, 1997)

For these reasons, assessment of music performance presents “continual problems of interrater reliability due to its inherent subjectivity (Elliot, 1987; Levinson, 1987; Mills, J, 1987)” (Haroutounian, 2000:139). Measurement of “musical quality” (one of the criteria in the McPherson TAI task) may also be challenging because there exists no universally agreed-upon definition of musical expression (Juslin & Timmers, 2010:454) nor agreement on theory of aesthetic appraisal of music (Juslin & Timmers, 2010:477) nor any consensus among academics regarding the meaning of the term ‘musicality’ (Hallam, 2006:93).

The issue of aesthetics in music performance is highly complex and this issue will be discussed in more detail further on. Many authors, however, stress the importance of audiation in generating an aesthetically appealing musical performance. It is therefore an important concern in audiation measurement, that it is possible to create so-called improvisations algorithmically, that is, using rules and formulas, without any need for audiation. That is, rather than relying on an imagined sound—audiation—to generate sounds on an instrument, improvisation can be approached from a
theoretical aspect—knowing which sequence of buttons to press—or a purely gestural approach, knowing which finger patterns will generate acceptable sounds. Because of the difficulty of establishing whether a music performance is generated by audiation or by a non-musical basis, a study involving measurement of audiation through the assessment of improvisation or any kind of music performance may not be optimal for this present study.

**Self Report Studies**

In the course of preparing this present study, several music education researchers raised concerns about the study design because it did not incorporate any measure of self-beliefs about audiation skill. The concerns were strongly enough voiced as to warrant addressing here in some detail.

Since the latter half of the 20th century, an important area of research has focused on people’s motivation for skill acquisition and achievement. In particular, a great deal of emphasis has focused on people’s self-perceptions of their abilities and how these self-perceptions influence their motivation and success or failure at a given task. In most of this kind of research, data are gathered mainly by asking people about their experiences, through self-report via written questionnaires or verbal interviews, as well as think-aloud protocols where participants verbally report on their behaviors before, during or after performance.

Klein (2012:253) observed, however, that despite the abundance of hyphenated self compounds “there is perhaps no term in psychology that is more widely used, yet less well-understood, than ‘self’”. The traditional idea of a unified self, or central executive involved in performance and learning has been found by a range of brain researchers to be flawed (Cosmides & Tooby, 1997; Damasio, 2006; Dennett, 1991; Gazzaniga, 1985; Lewicki, Hill, & Czyzewska, 1992).

The idea that most of what we see, hear and feel is not available to the conscious self has been described as one of the most significant discoveries of the human mind in the last 150 years (Snyder, 2009:108). It also counter-intuitive to our experience. As Kahneman, says,

> the notion that we have limited access to the workings of our minds is difficult to accept because, naturally, it is alien to our experience, but it is true: you know far less about yourself than you feel you do. (2011:52)

This lack of access to knowledge of the self is particularly relevant in many areas of music skill acquisition which require memory for execution, but “those memories are not available to consciousness, and cannot be described verbally” (Snyder, 2009:108). This is particularly relevant to the area of audiation skill. Karpinski (2000:37), for example, points out that pitch memory is
CHAPTER 4: PREVIOUS MEASUREMENT OF AUDIATION

coded in a nonverbal way. Lewicki et al. (1992) note that cognitive researchers have largely abandoned verbal self-report as a way of gathering data on how people process complex nonconscious information. For this study, therefore, methods involving self-report may not be appropriate. Acknowledging, however, the growing interest in self-report in music research, it may be valuable to include some element of participant opinion on the value of audiation in music performance expertise.

Measuring Melodic Pattern Audiation

Melodic patterns rather than individual pitches are the basis for audiation. Pattern audiation has been identified as a fundamental aspect of learning music (Gordon, 2011:9), and an important step in more complex tonal understanding. Gordon (2007:104) suggested that the ability to audiate differences among melodic patterns develops with the practice of listening and copying. Some research suggests that aural musicians may process melodic patterns more efficiently than reciting musicians (Woody & Lehmann, 2010:113). This was supported by Seppänen et al. (2007) and Tervaniemi et al. (Tervaniemi et al., 2001). This may also support the idea that audiation of melodic patterns can be developed with certain types of musical practices.

Audiation involves listening to music while simultaneously comparing it with other musical sounds. Numerous tests of audiation are based around same-different frameworks, where listeners hold one pattern in mind while comparing it with a subsequent one. Because of this, several researchers have cited the essential role that musical working memory plays in same-different tests (Holahan et al., 2000; Royal, 1999; J Ruthsatz et al., 2002). Some researchers suggest that results on same-different tests may “represent not talent or musical intelligence but ability, reflecting differences in working memory capacity.” (Berz, 1995:362). Same-different tests may be an effective measure of musical working memory.

One obvious limitation of same-different tests concerns ecological validity. As Sloboda (1988:152) noted, the brief nature of the patterns in same-different tests “hardly present listeners with the range of patterns and relationships which they must deal with in even the simplest short song”. He writes,

The normal inference drawn from such studies is that if a listener can reliably tell when a particular type of difference is present, then he extracts this information in normal listening, and conversely, if he cannot reliably detect a difference, then he does not extract such information in normal listening. In fact, neither inference is necessarily valid. (Sloboda, 1988:152)

Clearly, same-different tasks do not represent “normal” music listening. But the building blocks of these tests are melodic patterns and therefore in this sense they seem to be a step beyond the many
tests which use what are often referred to as “atomistic” elements of music such as chords and intervals. The requirement to hold patterns in mind and discriminate between them seems at face value to represent an important aspect of audiation, and also a test of musical working memory. Because of this, same-different tests may represent an acceptable “trade-off” in the search for a balance between ecological validity, and internal validity.

Another important aspect of same-different melodic pattern tests is that they do not require any theoretical or notation skills. This is particularly important in any attempt to test musicians whose training may not have focused on those skills. Same-different pattern tests are convenient in that they can be administered either individually or in large groups. For these qualities, as well as their potential to test pattern audiation and musical working memory capacity, a same-different test may represent a valid method for this present study.

**Advanced Measures Of Music Audiation**

Initially, Gordon’s (1989) Advanced Measures of Music Audiation (AMMA) seemed potentially appropriate for this study for several reasons. As its name suggests it is designed to measure audiation in advanced music learners. It is aimed at individuals or groups of students at secondary and tertiary level as well as professional musicians and non-musicians (Gordon, 1989). It is also brief, approximately 15 minutes. It includes extensive results data for thousands of students in the United States for potential comparison with Australian results. Importantly it does not require knowledge of notation or theory. The AMMA was piloted informally with the researcher, colleagues from various musical backgrounds, several tertiary students from various musical backgrounds, as well as several non-musicians.

Results on the informal pilot tests indicated some anomalies. For example, some popular musicians who were known to the researcher to have highly developed tonal understanding scored poorly, while some non-musicians known to have limited audiation scored just as highly, or higher. The AMMA did not seem to be an accurate reflection of a person’s audiation achievement, but rather something else. Similar anomalies in results of the AMMA were reported anecdotally to the researcher by several music academics and researchers who had used the test and also found inconsistent results.

These anomalous results on the AMMA are supported by a study by Seppänen et al. (2007). They used the AMMA to compare the audiation of 13 aural musicians and 11 reading musicians and found some strongly counter-intuitive results on the AMMA. The reading group had higher total scores (M D 71.91, SD D 18.98) than the aural group (M D 57.62, SD D 12.76). And tonal scores were significantly higher in the non-aural group (M D 78.0, SD D 18.0) than in the aural group (M D 63.85, SD D 13.93). Seppänen et al. (2007) commented that results on the AMMA did
not correlate significantly with the classification of musicians into the aural or reading groups. On the face of it, the aural musicians in the Seppänen study should have done better on a test of audiation than the reading musicians.

The results of the AMMA in the pilot study, anecdotal evidence, and the Seppänen (2007) study appeared to call into question the validity of the AMMA for measuring audiation achievement. Researching the test further it became clear that the source of these inconsistencies may have been due partly to the test having been designed to measure music aptitude, rather than achievement (Gordon, 1998:111). Gordon (1998 :111) makes a clear distinction between the two things: “the AMMA is misunderstood by some persons to be a music achievement test. It is a music aptitude test”. He explains that the test was carefully designed to measure aptitude rather than achievement (Gordon, 1998:111). Gordon (1989:5) confirms the potential for anomalous results by making clear that because it is designed as an aptitude test, a person may score extremely highly on it, without demonstrating any musical achievement. As the focus of this study is on levels of audiation achievement, the anomalous results on the AMMA suggested that it was an unsuitable instrument for this study.

Measuring Tonal Understanding

There are numerous kinds of understanding in music and two fundamental kinds are understanding of rhythm and pitch. Understanding the pitch content—the harmony and melody—of a passage of tonal music is referred to here as tonal understanding. Tonal understanding is enabled by three pitch understanding skills in sequence: establishing the tonal centre, recognition of contour, and identification of scale degrees (Karpinski, 2000:82).

Tonal understanding plays “a central, indispensable, and predominant role” in formal music training (Karpinski, 2000:95). In spontaneous music expression it plays a central role allowing musicians to translate heard melodies and harmonies—real or imagined—and to reproduce them onto an instrument, or in notation.

None of the above mentioned studies have specifically targeted measuring tonal understanding in musicians. Many of the studies were aimed at measuring musical aptitude or perception of atomistic musical elements such as intervals. Several studies however, may be said to indirectly measure tonal understanding. Studies using playback methods, for example, could be said to require some level of musical understanding in order to translate heard sounds onto an instrument. The same could be said for any tests involving melodic dictation, where heard sounds are translated onto notation.
Music Transcription

A way of measuring tonal understanding that avoids some of the problems of play-back is music transcription. Transcription is the process of transferring heard (or imagined) music onto notation. Music transcription is analogous to text transcription in that it requires comprehension of what is heard in order to write it down. Music transcription is the skill that allows Beethoven and others to identify heard musical sounds, whether actual or imagined, and transfer them onto an instrument or notation. In this sense, music transcription offers evidence of tonal understanding.

In formal music training transcribing is widely used not as an end in itself but rather to develop many important skills including tonal understanding, extractive listening and musical working memory (Karpinski, 2000:62). In the US, accredited music schools at the tertiary level are obliged to teach transcription skills in undergraduate programs (NASM, 2012 from Paney 2014). Most aural skill texts emphasize it, and it features prominently in many tertiary aural training courses (Karpinski, 2000; Klonoski, 2006).

Transcribing is an acknowledged way of ascertaining levels of tonal understanding in musicians and has been described as possibly the best measure of progress in aural training (Klonoski, 2006) and essential to musicians (Pembrook, 1986:239). In many parts of the world, melodic transcription tasks are commonly used in tertiary entrance tests as a way of gauging musical understanding. In the US, a major entrance examination for tertiary music schools includes a large element of melodic transcription tasks (College Board, 2012b in Paney & Buonviri 2014:397). It is also widely used at the tertiary level in examinations. In Australia, a transcribing task is usually present in Year-12 final music examinations in most states.

Transcription Research

Despite the widespread use of melodic transcription, published guidelines or principles for assessing transcription are described as “rare” (Karpinski, 2000:104). Until relatively recently, there has been a “paucity of research” into transcription (Pembrook, 1986:240) with few studies dealing specifically with melodic transcription, beginning with Ortmann (1934) who conducted several studies of melodic transcription that examined among other things problem areas of the melodic transcription process.

Melodic Transcription Task

A melodic transcription task offers several distinct advantages as a test of tonal understanding. One of the important qualities of a melodic transcription task is its ecological validity. The act of transcribing heard music mimics the listening-copying practices of many musical genres. These practices involve listening to music, understanding it and translating it, usually onto an instrument, but often onto actual notation, or chord charts, in order to learn and play
melodic solos, bass lines, vocal parts and harmonic progressions. In this sense, transcription is a musical process that is common across musical genres.

The ecological validity of a transcription task is especially evident where the excerpt to be transcribed consists of authentic pre-existing music. This real-life aspect of transcription is in contrast to contrived musical material identified in much aural-training in formal music education. Pratt, (1998:1) noted that “to meet the demand for assessment, much aural training is directed towards testing of what is right or wrong, and the most convenient material for this is the pitch and duration of notes.” As Pratt has pointed out, most aural training programs are based on training students to memorize pitch and duration information in order that they will be able to later recognize them in a test and be able to give the right, or wrong, answer.

Goldberg (2009) has raised concerns about the pervasive and problematic nature of “right and wrong” frameworks in a wide range of memory testing which has significant implications for the design of this study. He suggests that most real-life acts of memory-recall require decisions about what information is useful, and then selecting that information from out of all the knowledge available. Memory based on these decisions and selection process are handled by working memory. He suggests that to reflect how memory processes work in real life it is important to include a selection component and decision making about what to focus on (Goldberg, 2009:93).

Transcribing is a more complex process than a right-and-wrong test. Performance in transcribing tasks is greatly improved by developing appropriate strategies and information in long-term memory (for example, verbal labels, musical syntax) (Berz, 1995:361). Transcription involves decisions about which aspects of the music to focus on, which elements to isolate and extract, and which strategies to employ to achieve the transcription. As Klonoski (2006:55) says, “Dictation isn't a single activity; it is multifaceted, requiring numerous listening skills and a clear understanding of how to integrate those skills in support of one another in a unified listening experience.”

An important aspect of melodic transcription is that it is likely to place significant demands on musical working memory. This is because of competing needs of storage and processing (Berz, 1995:361). Berz (1995:361) and Karpinski (2000:77) believe transcribing develops musical working memory and that it can be improved with training and practice. Listeners skilled in transcription understand elements of music such as scalar passages, triads, sequences and modulations. This allows them to encode music into meaningful chunks, reducing the number of “bits” in a heard passage and freeing up musical working memory (Karpinski, 2000:73).

Less skilled listeners lack this chunking ability and musical working memory operates less efficiently (Karpinski, 2000:73). This chunking ability is an important goal of aural training: “listeners who chunk are thinking analytically, functionally, and structurally” (Karpinski, 2000:77). This may help to support claims about the high levels of audiation skills reported in aural musicians who often
engage in activities similar to transcribing. A transcription task may be an effective way of measuring tonal understanding, including musical working memory skills, in an ecologically valid way.

**Extractive Listening**

In addition to chunking, the only other way of extending musical working memory capacity is thought to be “extractive listening” (Karpinski, 2000:71). Extractive listening is “the ability to focus attention on a selected segment of a musical stimulus and remember that segment despite the inhibitive nature of surrounding musical material” (Karpinski, 2000:72). Extractive listening is a “fundamental musical skill” (Karpinski, 2000:72) and for those who develop it:

their music listening proficiency improves in a variety of settings. Their aural acuity in the concert hall, classroom, and ensemble becomes much more flexible and manageable. Their ability to focus attention and retain specific musical information becomes extremely valuable while listening, performing, studying, conducting, composing, and teaching. (Karpinski, 2000:73).

Karpinski (2000:72), notes that “there are many developing listeners for whom this is a difficult task”.

Extractive listening skills appear to be strongly implicated in the listening-copying activities of aural musicians. The process often involves aurally isolating specific parts of music and extracting bass-lines, vocal melodies, instrumental solos, or rhythmic and melodic patterns and riffs from the totality of sound in recordings and performances. Transcribing is thought to be an important way of developing these extractive listening skills, and thereby increasing musical working memory (Karpinski, 2000:62). The element of extractive listening has important implications for the design of this study. When designing a transcription task, it should involve some element of extractive listening.

**Background To Transcription Selection**

The initial idea for this present study was to compare the audiation abilities of popular (non-reading) musicians with formally trained (reading) musicians. In this initial conception, it seemed important to avoid methods that involved the need for notation skills, as this would be biased against those participants who were purely aural learners. Gradually, however, it became evident that most musicians whether popular or classical were knowledgeable to some extent about notation, and most had experienced some kind of formal training in theory and harmony. The sampling frame then changed to music students at tertiary institutions. This change of population sample allowed the possibility of introducing a task that involved some use of music notation such as a transcription task. Developing a transcription task became the focus for testing tonal understanding.
CHAPTER 4: PREVIOUS MEASUREMENT OF AUDIATION

Selection of an appropriate test to measure tonal understanding in trained musicians involved addressing several important factors. The transcription task needed to measure tonal understanding at a level appropriate and representative of musicians in tertiary training, without exhibiting large floor or ceiling effects. This meant establishing a reference point for appropriate difficulty level of the task. It also was important to establish the validity of the test, and a reference point with which to compare the results of this study.

In Australian secondary education at final year 12 level there is a wealth of existing transcription tasks, which have been rigorously designed, tested, implemented, assessed and validated for use with final year music students. This appeared to be a potentially useful source for selecting a transcription task suitable for this present study.

An important advantage of using one of these transcription tasks for this present study is that a great deal of attention is paid to their design. They are the result of considerable discussion and extensive consultation by a reviewing panel of experts, including musicians, educators and assessors. The type of music used, the length of the excerpt, number of listenings, and general level of difficulty are all rigorously vetted by the examining body to ensure the task is appropriate to measure transcription abilities at the end of secondary music education. The added advantage is that often these transcription tasks are accompanied by their own assessment rubric to evaluate test results. For their potential application to this study numerous past examples of these transcription tasks were reviewed.

**Year 12 Transcription Tasks**

The search for an appropriate transcription task began with a review of previous tasks from past years of the Year 12 music examinations in Victoria. These were available on the website of the Victorian Curriculum and Assessment Authority (VCAA), the government body responsible for the provision of curriculum and assessment for the Victorian Certificate of Education (VCE) exam. An important consideration in selecting a test was to avoid as much as possible the potential for prior exposure effects. For this reason any transcription tasks which may have been familiar to recently past VCE students, that is from 2007 onwards were excluded.

Several transcription tasks from the VCE past exams were trialled informally by the researcher before piloting of the transcription task from the 2003 VCE music examination (VCAA, 2015). The musical excerpt for this task was four bars of chamber music for Flute, Vibraphone, Trombone and Bassoon. The task required transcribing the vibraphone part. It was constructed specifically for the examination and recorded using synthetic MIDI instruments. The tempo was slow (crotchet = 54). A key signature of one sharp was given.
In the year before the main study, the 2003 transcription task was piloted. 20 people participated. All were trained musicians currently enrolled in a teaching degree at a major university. There were eight males and twelve females aged between 21 and 39 from diverse music backgrounds: five popular musicians, nine classical musicians, and six who played a mixture of musics. All participants had already obtained a Bachelor of Music or equivalent in their particular genre.

The VCAA website did not provide a rubric for scoring the results of the pilot. However, the task was reported on the website to be worth 15 marks. As the task has almost exactly 15 crotchet beats, the researcher awarded one mark for each correctly transcribed crotchet beat.

Results showed significant ceiling effects, a fact corroborated by comments from the examination website which noted that most Year 12 students had transcribed this melody reasonably well (VCAA, 2015). Numerous results of the pilot showed difficulty with a rhythmic aspect of the task which clearly distracted from the more important melodic aspects of the task.

The task also appeared to be lacking in ecological validity. The VCE transcription tasks are specifically constructed for each examination. The 2003 excerpt appeared to exhibit what Pratt (1998:4) has described elsewhere as a melody “of studied anonymity, written by last year’s Board of Examiners”. The use of MIDI generated sounds for the recording created a lifeless feel lacking in real-life musical nuance. Pratt (1998:4) proposed that transcription tasks using real musical excerpts have “enormous” methodological and musical advantages and can be tailored to suit requirements.

The transcription tasks of the New South Wales Year 12 Higher School Certificate (HSC) examinations differ importantly from the Victorian examinations in that they use music taken from the real world. Thus they incorporate an important element of ecological validity. The HSC transcription tasks are carefully prepared by N.S.W. Board of Studies (BOS) (Studies, 2015) to be at an appropriate level to reflect musical understanding skills achieved at the end of secondary schooling. Selection of the excerpt for the transcription task undergoes a rigorous vetting process by a team of six researchers who are experienced in the area. The excerpt goes through various processes before the assessor trials the examination paper from the point of view of the student before finally being selected as appropriate. For their potential application to this study numerous past examples of these transcription tasks were reviewed.

Several past HSC transcription tasks were trialled informally by the researcher and musician colleagues before piloting the transcription task drawn from the 1997 HSC music exam of the BOS. The 1997 transcription task uses an 8-bar excerpt from Carl Vine’s (1993) Battlers Suite for small chamber orchestra. The composer is a recognized musician, and the excerpt is taken from an actual recording by professional musicians. The audio quality is high. The task requires transcribing the oboe melody. A blank stave is given, with a key signature of one sharp and the starting note: ‘D’. There are six playings with timed pauses in between. The task was administered to several small
groups of tertiary music students and some musical colleagues. Perhaps because the melody is diatonic and relatively simple and played at a slow tempo there were large ceiling effects with this task and it was considered unsuitable for the present study.

The transcription task from the 2006 HSC Music 2 Exam (Studies, 2015) was then trialled informally with the researcher and several musical colleagues. The musical excerpt used for this transcription task is the first eight bars of the Prokofiev Violin Concerto No. 2 in G minor. The task was to transcribe the violin part. Several problems were identified with this excerpt for the purposes of this study. The first problem was that the complex rhythmic aspect of the excerpt seemed to outweigh the melodic complexity. This had the potential to require too much focus on the rhythmic aspect of the piece and weaken and confuse the results on the pitch aspect of the task. This was supported by comments from the examiners of the original HSC task.

Another significant problem was the strong potential for prior exposure effects. The excerpt is an unaccompanied solo from a well-known classical violin concerto. It seemed likely that many classical violinists would be familiar with the piece, and may even have played the first few bars. This problem of familiarity extended even to most classical musicians, who might be familiar with the piece in some way, including knowing the key of the piece. This had the potential to bias the results towards classical musicians, and particularly string players. The solo instrument nature of the excerpt also meant that the important aspect of extractive listening was missing from the task. For these reasons the excerpt was considered unsuitable for this study. Further trialling led to the selection of the music transcription task used in this study. This is described in the next chapter.

**Conclusion**

The purpose of this chapter was to review information on audiation measurement that would inform the design of the study. The chapter identified a range of problems in many of the methods available to measure audiation in musicians. Many of these problems centre around the issue of trying to balance ecological validity with the need for internal validity. This suggests that an optimal approach to testing for tonal understanding should incorporate as far as possible methods that resemble a normal music-listening experience. The preceding literature has suggested that for this present study:

1. A same-different melodic pattern test may provide a suitable measure of musical working memory.
2. A melodic transcription task involving an authentic musical excerpt demonstrates several important qualities as a test of tonal understanding. These include:
   - It is widely used in formal education to develop tonal understanding and musical working memory.
• It is widely recognized in formal music education as an effective method of measuring tonal understanding.
• It demonstrates ecological validity as it mimics the listening-copying practices of numerous musical genres.
• It requires extractive listening skills
• It can be used with individuals or large groups.

Based on this review of the literature, this study assumes that the skill of tonal understanding is a clearly identifiable process which can be measured and assessed. The study also assumes that tonal understanding and melodic pattern audiation develop through some kinds of musical practices and training.

The research reported in the following chapters uses 340 tertiary music students from all Australian states. It includes a description of the design of the study, together with a description of the sample, procedure and measures used.
CHAPTER 5: RESEARCH DESIGN

This study was designed to investigate the nature and extent of audiation skills, and specifically tonal understanding in Australian tertiary trained musicians. The major purpose of the study was to establish whether claims in the literature about audiation in trained musicians were supported by empirical evidence.

A first priority was to gather empirical information about the ability of tertiary trained musicians to understand tonal music and to audiate melodic patterns. The purpose was to examine the degree of association between audiation and factors that might impact on that ability, such as training or pre-existing characteristics. An extension of this analysis was to use regression analyses to predict tonal understanding and melodic pattern audiation in trained musicians.

In order to fulfil these objectives, a study was devised that used students who were studying music performance at an Australian tertiary music institution. Entry into an Australian tertiary music course was used as an indication of some degree of previous musical training. A further requisite for the study was to find or develop appropriate instruments to measure tonal understanding and pattern audiation, and to gather background information about music learning.

The first part of this chapter explains the rationale for the sample, and describes how the sample was selected. The second part of the chapter covers the development and selection of a test of tonal understanding and a melodic pattern audiation test and information on the administration of the tests and the scoring of results. There is also a section on the development and administration of a researcher designed questionnaire used to obtain additional relevant information. The final part of the chapter outlines the procedure for the study, and includes information on the individual sessions with each group of students, the equipment used for each session and the preparation of the data ready for analysis.

As a result of the previous review of literature, this study aimed to answer the following nine research questions.

Research Questions: Melodic Pattern Audiation

Question 1: What structural elements of melodic patterns are associated with audiation difficulty?

An important focus of this study was to investigate what background factors may be associated with differences in melodic pattern audiation ability in trained musicians. In this study, melodic pattern audiation was measured using the melodic section of the Musical Ear Test (MET) (Wallentin, et al. 2010). The choice of this measure, and the measure itself, are discussed in detail later in this chapter.
Pattern recognition in general is the process of matching current perceptual experience with representations held in long-term memory (Snyder 2000:23). In music, a mental representation of a melodic pattern and structure needs to be created and maintained in working memory as the music is being heard. This representation is simultaneously compared and contrasted with representations of melodic structures stored in long-term memory from prior musical experience. This process of retrieval and comparison of mental representations enables the listener to anticipate and confirm contour and perception of tonality created by the pitches.

The process of melodic pattern audiation requires cognitive effort. The amount of cognitive effort required to audiate pairs of melodic patterns varies depending on a number of factors including some structural features of melodies (Holahan & Saunders, 1997; Saunders & Holahan, 1993). To assist with the analysis of the results on the MET, the structural features of each individual item were examined. The MET results were then analyzed according to the following structural variables.

**Tonality**

One of the aspects thought to contribute to difficulty level in melodic pattern audiation is predictability. Predictable melodies—those that conform to the storehouse of melodic structures built up in long term memory—require much less cognitive effort to perceive than unexpected melodies such as atonal ones (Holahan & Saunders 1997:85). This suggests that in audiation of melodic patterns, the tonal quality of a pair of patterns—either tonal or atonal—is likely to contribute to item difficulty level.

**Sameness and Difference**

Also thought to contribute to difficulty level in audiation of melodic patterns is sameness or difference. Gordon (2007:223) found that pattern sameness was easier to identify than difference, and a greater cognitive load has been found to be associated with recognizing pairs that are different (Holahan & Saunders, 1997; Saunders & Holahan, 1993).

**Type of Difference**

Audiation difficulty is also associated with the type of difference in a pair of melodies. Differences in pairs may be effected by a change in contour, a change of pitch or both. It has been found that melody pairs with a similar contour but with a pitch alteration require greater cognitive effort (Holahan & Saunders, 1997; Saunders & Holahan, 1993).

The type of pitch change has also been cited as a factor in audiation difficulty. For those pairs of melodic patterns that contained a pitch change, small intervals of change were found to be harder to perceive than larger intervals (Holahan, Saunders & Goldberg 2000:164).
CHAPTER 5: RESEARCH DESIGN

**Number of Tones**

Because of the storage limitations of working memory, it seems likely that the more notes in a pattern, the more effort would be required to audiate the pairs. Holahan, Saunders and Goldberg (2000:174) suggested that even simple three-note patterns placed significant cognitive demands on the non-musicians compared to the musicians. The items in the MET contain from three to eight tones and are much more complex than three-note patterns. This means the MET is likely to place significant cognitive demands on trained musicians.

**Test Item Number**

The MET requires relatively intense concentration for ten minutes. Because of the demands placed on musical working memory, the sequential order of appearance of an item in the test—for example towards the end—could potentially cause reduced performance on some items due to loss of concentration.

**Question 2: What degree of association exists between melodic pattern audiation and musical training?**

A common assumption throughout the literature on audiation is that it is amenable to appropriate practice and training. Some types of musical training and practices such as those based around aural learning and performance are thought to be more conducive to the development of audiation than some practices based around notation (Campbell, 1987; Green, 2002; Woody & Lehmann, 2010). The assumption that musical training may enhance audiation implies that the extent of training may be an important factor in audiation development.

Therefore, to assist the analysis of the MET results, information was gathered on participants’ musical training and organized in two categories: type of training and extent of training. The results on the MET were then analyzed according to the following variables.

**Type Of Training**

This included information about the main type of music a participant played and how they learned, whether they were largely self-taught, or had received lessons, and whether the lessons were based on a particular school of teaching such as Kodaly or Suzuki. Included in this category was the type of instrument that a person played. Musical instruments are likely to vary markedly in their demands on melodic pattern audiation. Single line melodic instrumentalists for example, are likely to rely more on melodic pattern audiation than percussionist who are often primarily focused on the rhythmic aspects of performance. Training on some instruments therefore could be more likely to enhance melodic pattern audiation than others. Also included in this category was information on whether lessons involved any type of teaching method. The Suzuki, Kodaly and Yamaha teaching methods for example, are thought to emphasize audiation development.
Extent Of Training

The assumption that melodic pattern audiation is associated with musical training suggests the possibility that the amount of musical training may be an important factor. Information was gathered on the extent of training including the amount of time since a participant had started learning an instrument.

Another indicator of time spent learning an instrument is the level of instrumental examination achieved. As a general guide, one examination grade level requires one year of training. Grade 6, for example, suggests approximately six years spent preparing for examinations. Table 1 shows an approximate guide to the relationships between AMEB grades, age, and years of training.

For the purposes of this study, the level of a Grade 6 instrumental examination represents a notional indicator of instrumental training equivalent to the end of secondary schooling. Grades achieved beyond this level represent tertiary level instrumental training.

<table>
<thead>
<tr>
<th>Years of tuition</th>
<th>AMEB Grade</th>
<th>School year</th>
<th>Age</th>
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<td>4-5</td>
<td>9-10</td>
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<td>2</td>
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<td>8</td>
<td>6-7</td>
<td>12</td>
<td>17</td>
</tr>
</tbody>
</table>

After McPherson (1993:85)

Another useful guide to the extent of musical training was whether the participant had studied music as a Year 12 subject at secondary school. Study of music at the Year 12 level generally implies prior instrumental music experience, usually several years of previous training on the instrument. Similar information was gathered about tertiary music training.

Question 3: What degree of association exists between melodic pattern audiation and pre-existing traits?

Participant characteristics that exist outside of musical training are also potentially associated with melodic pattern audiation. The most obvious is perfect pitch. Possession of perfect pitch was clearly likely be an important factor in any test of audiation and occurs outside of training. There is a known association between the incidence of perfect pitch and a person’s native language. Some Asian tonal languages for example are known to have a higher proportion of people
with perfect pitch than other languages. It was therefore important to gather information about participants’ native language. Also included in this category was gender, age, and the value that a person attributed to audiation skill as part of music performance expertise. Finally, partly in response to the importance stressed by some academics, a question was included which sought participant opinions on the value they placed on aural skills as part of becoming an expert musician. This information was important for another reason: attention to the tasks. Both tests demand relatively intense focus. Listeners need to attend to the musical passage with enough concentration that it reaches their short term memory. The value a participant attributed to the task was likely to be associated with their attention to the task.

**Question 4: To what degree can melodic pattern audiation be predicted from training and pre-existing variables?**

An important phase of the analysis involved developing a model using regression analysis to determine the relative importance of each of the independent variables, in order to predict melodic audiation in musicians from the measures of training and pre-existing traits used in this study. This was seen as an important step in answering the question as to what factors are associated with melodic pattern audiation.

**Research Questions: Tonal Understanding**

**Question 5: To what degree do trained musicians understand heard tonal music?**

A principal aim of this study was to investigate numerous claims in the literature that many musicians do not have tonal understanding of music they hear, but rather rely on other non-audiation processes. It was therefore a primary goal of this study to gather empirical data on the tonal understanding of participants. In this study, tonal understanding was measured using a music transcription task (MTT). The choice of this measure, and the measure itself, are discussed in detail later in this chapter.

In order to answer the research question, it was necessary to establish the degree of difficulty of the music transcription task (MTT). In order to do this, the structural features of the melody will be examined. In addition, to assist in the analysis of the MTT results, the results of this present study were analyzed in comparison with data from the original 2001 secondary school group.

**Question 6: What degree of association exists between tonal understanding and melodic pattern audiation?**

Because the MTT required a functional knowledge of notation, it was important to allow for the possibility that some participants had limited skills in notation. Partly to account for this possibility, the MET was chosen because it is a non-notation test: it requires no functional knowledge of notation at all. This non-notation feature of the MET allowed for a potentially important source of
triangulation of the tonal understanding data. An analysis of the correlations between the two tests would provide evidence of a potential bias against those with limited notational skills.

**Question 7: What degree of association exists between tonal understanding and musical training?**
As explained for this question relating to the MET, to assist with the analysis of the results on the MTT they were analyzed according to information gathered on type and extent of training.

**Question 8: What degree of association exists between tonal understanding and pre-existing traits?**
As explained above, characteristics that exist outside of musical training are also potentially associated with tonal understanding. Results of the MTT were analyzed in relation to pre-existing variables.

**Question 9: To what degree can tonal understanding be predicted from training and pre-existing variables?**
It was also important to develop a predictive model for tonal understanding using regression analysis to determine the relative importance of each of the independent variables, in order to predict tonal understanding in trained musicians. It is of interest, first, to find whether tonal understanding can be predicted from the variables measured in the survey, and secondly, if so, which of these variables are most strongly predictive.

**Participants And Recruitment**

**Rationale For The Sampling Frame**
The initial impetus for this study was the marked distinction in the literature, as well as anecdotally, between formally trained classical musicians and informally trained “popular” or “vernacular” musicians (Green, 2002; Woody & Lehmann, 2010). A broad distinction in the literature suggested that formally trained musicians attended music institutions, learned from teachers and mainly learned and performed by reading from notation. Informally trained popular musicians were thought to be largely self-taught, avoided institutions, lessons and notation, and learned mainly aurally, by listening and copying. Popular musicians were thought to have superior audiation compared to their formally trained peers. A comparison of these distinct groups, and between musical practices, seemed worthy of investigation and had the potential to offer valuable information about the development of audiation.

Subsequent discussions with numerous popular musicians known to the researcher in the professional music scene indicated that the neat division portrayed in the literature between types of musician was not readily apparent in Australia. According to the discussions, genuinely self-taught musicians appeared to be a rare phenomenon. Those popular musicians I had presumed to be self-
taught had all experienced some kind of formal training. Almost all had taken some form of instrumental lessons and this generally included learning to read notation. Often these lessons included preparation for examinations with an external instrumental examination body such as the Australian Music Examinations Board (AMEB). Many popular musicians had been exposed to formal music training through secondary schooling.

The recent absorption of jazz and popular musics into formal music institutions appeared to have further contributed to this situation. It is now common for tertiary music programs to offer courses based on popular musics such as jazz, rock and music theatre with many courses specifically focused on developing instrumental improvisation skills. Many musicians playing popular music had been through some kind of formal music program at a tertiary institution.

The neat divide between types of musical training is also questioned in the literature. Increasingly the categories of formal and informal training are seen not as a dichotomy, but poles of a continuum where crossovers are apparent in most learning situations (Folkestad, 2006). At this point, the focus of the study moved to a more global view of the music learning population. In Australia most music institutions now offer popular as well as classical music programs and thus contain mixed populations of types of musicians. This eclectic population of musicians from various learning backgrounds was considered an optimum source of participants for this study.

The aim of the study was to survey audiation in musicians who had completed, or were nearing completion of their musical training at a formal music institution in Australia. This required approaching all the tertiary music institutions within Australia for participation.

**Australian Tertiary Music Institutions**
In Australia, tertiary music education is organized into the following categories.

**Universities**
Each state has several universities in capital cities and regional areas. All of these offer some form of music training. Most universities also offer courses in music teacher education. There are also universities of technology which often have an emphasis on training in skills aimed at industry, many of these offer courses in music and teacher education. Entry into these institutions requires some level of demonstrated music performance expertise.

**Music schools and conservatoria**
Connected to the main universities in most states are music schools and conservatories dedicated to the study of music. Courses range from Diploma and Bachelor degrees through to postgraduate studies. Many of these music schools focus on classical music, but increasingly many
also offer courses in popular music. Entry into these institutions is usually highly competitive and requires demonstration of high levels of instrumental music performance expertise.

**Specialist performance institutions**

There are also specialist performance institutions. The Western Australian Academy of Performing Arts, for example, offers courses in classical performance, composition; jazz; contemporary music; as well as music teacher education. The Victorian College of the Arts offers courses including improvisation, composition and music theatre. The Australian National Academy of Music focuses uniquely on the performance of classical music and entry is limited to instrumentalists who demonstrate high levels of music performance expertise.

**TAFE**

In each state there are a number of institutes of Technical And Further Education (TAFE). Originally focusing on vocational training (for example, tourism, hospitality, construction), some of these institutions now offer degree and diploma courses in music often with an emphasis on popular music. In Victoria, examples of these include the Box Hill Institute and the North Melbourne Institute of Technology. Entry into these institutions requires demonstrated music performance expertise.

**Institution Sampling Frame**

All of the principal tertiary institutions in each Australian state or territory offering a dedicated music performance program were approached to participate in the study. There are 19 of these. They are as follows:

- **New South Wales**: Southern Cross University; The University of New England; The University of New South Wales; The University of Newcastle; The University of Sydney; The University of Western Sydney.
- **Victoria**: Monash University; RMIT University; The University of Melbourne; Victorian College of Arts; Australian National Academy of Music
- **Queensland**: Griffith University; The University of Queensland
- **Western Australia**: The University of Western Australia; Western Australian Academy of Performing Arts
- **South Australia**: The University of Adelaide
- **Tasmania**: The University of Tasmania
- **Northern Territory**: Charles Darwin University
- **Australian Capital Territory**: The Australian National University
CHAPTER 5: RESEARCH DESIGN

In addition, three Melbourne institutions were approached partly for geographical convenience, but also because the two institutes of TAFE were known to the researcher to have strong music performance programs. The cohort of the Music Education department at the University of Melbourne was also considered suitable because it consists of trained musicians from a wide variety of backgrounds who are studying to be music teachers. The three additional institutions approached were:

- Box Hill Institute of TAFE
- Northern Melbourne Institute of TAFE
- University of Melbourne: Music Education

Ethical Approval

This study was conducted according to the guidelines of the University of Melbourne Human Research Ethics Committee (HREC). Informed written consent was obtained from all participants. Prior approval for the study was required by an application to the Melbourne Graduate School of Education Human Ethics Advisory Group (MGSE HEAG). The application required sufficient information to enable a full understanding of the aims, methodology and procedures of the research. Also required were copies of all documents relevant to the study including the following.

- The letter of introduction to the head of the music institution requesting approval to conduct the research in their institution along with a statement in plain language describing the research.
- The letter to the relevant lecturer requesting approval for their students to participate in the research along with a plain language statement describing the research.
- The letter to the student participants inviting their involvement in the research along with the plain language statement about the research.
- Consent forms for the head of school, lecturer and students.
- The musical background questionnaire, and the blank sheets for the audiation tests.

After review by the MGSE HEAG, the application was categorized as minimal risk and approved in October 2011 (HREC:1035233, MGSE HEAG ID 179/11) (Appendix 2).

Institution Recruitment

Once ethical approval had been granted, the next step was to approach each institution in order to seek participation in the study. This involved writing to the head of each institution giving
an outline of the proposed study and requesting permission to approach students to participate in the study. These letters also contained:

- Plain Language Statement detailing what the Head of School and the other participants would be required to do.
- Details of ethical approval from the researcher’s institution, including the condition of confidentiality and anonymity.
- Contact details of the researcher and the supervisors of the study.
- Exemplars of the forms that participants would fill in, including the student background questionnaire and the two blank test sheets.
- Consent form, which the Head of Department was asked to sign and to return to indicate support and permission for the study to proceed. (See Appendix 3).

Out of ethical considerations, all institutions approached to participate in this study were assured of strict anonymity for their institution, and confidentiality of all responses whether they participated or not. Therefore it is not possible to specifically describe the institutions which participated. It can be stated however, that at least one institution from each Australian state and territory participated in the study.

**Lecturer Recruitment**

Once formal consent was received from the head of department, the next step in the recruitment process was to obtain permission to invite class groups of students to participate in the study. This involved approaching the lecturer within the music department who was best positioned to facilitate the process of recruitment and testing. Often this was the lecturer responsible for aural training within the music department. I contacted the relevant lecturer by telephone where possible, or by email if necessary and advised the lecturer that formal approval for the study had been granted by the head of department. I explained the proposed study and asked permission to approach class groups of students about participating in the study. If the response from the lecturer was positive, copies of all relevant documentation were sent to the lecturer. This included:

- Plain language statement
- Consent form
- Exemplars of the questionnaire and blank test sheets

Once the lecturer returned the signed consent form, arrangements were made for the researcher, or proxy, to approach a class group of students to seek their participation in the study.
Modified Individual Sample

During preliminary discussions with lecturers, they often expressed interest in knowing what kinds of students were the target of this present study. Because this study was interested in the role that training plays in audiation development, the original intention was to sample students as near as possible to the end of their training, that is, in the final year of their course. In discussions with lecturers, however, it became apparent that this would be problematic for logistical reasons. In all institutions approached, class group sizes of final year students were significantly smaller and there were significantly fewer occasions on which they were obliged to attend the institution as class groups. Many lecturers agreed that this would make recruitment challenging and greatly reduce participation rates. In several cases lecturers suggested that the second- or even first-year students were more likely to be assembled in class groups and that these classes would be larger and more likely to yield useful participation rates.

Because enrolment at an Australian tertiary music institution usually requires significant prior musical training, it seemed worthwhile to modify the sampling frame to include earlier years than originally envisioned. The modified sample would provide very useful data for the survey. Therefore, in the interests of obtaining adequate numbers of participants, the sampling frame was adjusted to include students from any year of a tertiary music course.

Individual Participant Recruitment

Once formal consent had been obtained from the relevant lecturer to approach class groups, the final step in the recruitment process was to obtain participation from individual students. Recruitment of individual students was achieved by approaching classes of students in several different ways.

The main method of recruitment was that the researcher attended the institution at an appointed time and addressed the appropriate class in person. At these meetings with students, the researcher gave an outline of the study and distributed a plain language statement to all students. To encourage participation it was explained that the study was measuring the aural skills of music students at institutions around Australia. Two aural tests would take 10 minutes each to complete, and with the questionnaire the total time required would be about 30 minutes. It was emphasized that there was no obligation to participate but that the information gathered had the potential to benefit future music students, and that participation would greatly assist the study and be appreciated. The confidential nature of the study was also emphasized, and it was explained that all information gathered would be kept strictly anonymous and confidential and there would be no impact on students’ progress in their course. The students were also advised that if they wished they could receive feedback on their individual aural test results. This would be achieved by using codenames on all the test forms, and by contacting the researcher at a later date by email. At the end
of this explanation those students who agreed to participate remained in the classroom while others left. At this point, a consent form was distributed which was collected when signed. Testing then proceeded immediately after recruitment.

There were several recruitment sessions where attendance by the researcher was not possible. Australia is a large continent with regional cities separated by long distances, and with several time zones. Although the researcher made several interstate trips to attend testing sessions, geographical, financial or other logistical constraints meant it was not feasible to attend every testing site. In several of these cases, recruitment was achieved with the aid of communications technology. This included several occasions using a Skype internet link, and in one case a dedicated audio-visual conference link courtesy of the researcher’s institution. In these situations the researcher was visible and audible to the class of students, and vice versa during recruitment. This process involved sending copies of the plain language statements and consent forms to the relevant lecturer ahead of time which the lecturer then distributed and collected during the recruitment session. On one occasion recruitment occurred via a simple speaker phone so that only the researcher’s voice was audible to the class of students in the remote location.

In several cases it was not possible for the researcher to attend the session nor to arrange an audio visual link. Therefore in those sessions where the researcher could not be present, it was arranged for the lecturer to act as proxy. In these cases recruitment was done by the relevant lecturer. This included an explanation of the study and distribution and collection of documents and supervision of the subsequent testing session. An important part of the study design was that the recruitment and testing process was simple and self-explanatory. Before all of these recruitment sessions the researcher emphasized to the lecturer the importance of explaining to the students that there was no obligation to participate and that their choice would not impact in any way on progress in their course.

**Musical Background Questionnaire (MBQ)**

To assist in the interpretation of the results, and clarify the findings obtained from an analysis of the data of the main study a Musical Background Questionnaire (MBQ) was devised (See Appendix 7). The information for inclusion in the questionnaire was selected after discussions with several music education academics, and a review of relevant literature. This included reviewing several studies that had used music background questionnaires to seek similar information, such as cochlear implant researchers (Gfeller et al. 2000; Looi, 2008), and music researchers (McPherson, 1993).

One of the main constraints in the design of the questionnaire was time available for participants to fill in information. The McPherson questionnaire (1993:445-454) for example runs
CHAPTER 5: RESEARCH DESIGN

to nine pages and includes open ended questions. With the two main tests comprising 20 minutes, it was necessary that the questionnaire take approximately five minutes. This limitation therefore required the use of closed questions, multiple-choice and Likert-scale designs.

Part of the main aim of this study was to investigate what factors might be associated with audiation development in trained musicians. One of the key areas of interest was whether there might differences in audiation related to differences in ways of learning. The information sought was therefore organized into two main streams: information about the type and extent of training, and about pre-existing traits.

Self-Report

It was beyond the scope of this study to verify any of the information given in the MBQ. An important element of the study design was that all results be kept strictly confidential. This meant carefully guarding anonymity of the participants and no names were used on the test results. As a consequence of this it was not possible to verify any of the information given in the responses on the MBQ, even down to the age and gender of participants. Time constraints at the time of data collection also precluded the ability to verify the self reports about possession of perfect pitch.

One indicator that may suggest that all or most participants gave correct information, was the high importance placed on the value of aural skills, as indicated in an overwhelming number of responses to this item on the MBQ. (Of course, it is equally possible that even these responses were also false.) In addition to the response to the value of aural skills, was the demeanor of participants in the data collection sessions, which to the researcher indicated a serious attention to the task, and a genuine commitment to participating fully in the study.

In order to evaluate the effectiveness of the MBQ to elicit the right information to assist in answering the primary research questions it was piloted in conjunction with the tests of audiation. Participants included two university music educators, several professional musicians and 20 tertiary music students. Responses given on the MBQ in these initial trials indicated that the questions elicited the appropriate information. Where some confusion was evident, the wording of the item was amended to reduce ambiguity and improve clarity.

Measures Used In The Study

The preceding chapters identified two types of audiation that are thought to be strongly implicated in music performance expertise: tonal understanding and melodic pattern audiation. Tonal understanding refers to the ability to audiate and identify the pitch content—melody and harmony—of a heard, imagined, or notated passage of tonal music. This allows musicians to translate what they are hearing, imagining or reading onto an instrument or onto notation. Audiation is subserved in part by melodic pattern audiation, which is the ability to audiate and differentiate between heard melodic
patterns. Both of these skills are thought to be strongly linked to musical working memory capacity and susceptible to development with some types of musical training and practice.

In order to measure tonal understanding and tonal pattern audiation in tertiary music students two tests were selected. These were the Melodic Transcription Task (MTT), and the Musical Ear Test (MET). The following section discusses the selection and refinement of these instruments which was carried out during the year before the main study.

**Background To Test Selection**

One of the key challenges of the study design was gaining the support of academics and students to participate. To encourage participation, an important selling point was that the testing sessions would cause minimal disruption to the daily workings of a busy tertiary music school. An important priority in the design of the study therefore was to streamline the data collection process and minimize the duration of the tests and questionnaire.

Informal discussions about this issue with several tertiary music academics suggested that 30 to 40 minutes seemed to be the upper limit of time that academics and individuals would feel was reasonable to give up from their busy schedules. Therefore selecting the test instruments and designing the questionnaire involved a balance between obtaining the maximum of useful data in a limited amount of time. This time constraint automatically rendered many pre-existing psychometric tests impractical for the purposes of this study. Gordon’s Music Aptitude Profile, as an extreme example, is designed to be administered on three days, with each division taking 50 minutes, or almost three hours in total.

**Melodic Pattern Test**

The ability to audiate heard tonal patterns has been described as an important element of understanding tonal music (Gordon, 2007:ix). For the purpose of this study the melodic section of the Musical Ear Test (MET) (Wallentin et al., 2010) was used to measure tonal pattern audiation. One reason for choosing the MET was a limited range of alternatives. A review of available audiation tests indicated a lack of up to date and scientifically validated and reliable tests of tonal pattern audiation. Before selecting the MET, several other psychometric music tests were evaluated, as discussed earlier.

**Musical Ear Test (MET)**

The Musical Ear Test (MET) is similar in design to other same-different tests such as Gordon’s AMMA. Pairs of short melodic patterns are presented and listeners decide whether the pairs are same or different. It is a psychometric test and requires no knowledge of notation or theory. Responses are binary. This was an important consideration for selecting a test. Although most participants were likely to be familiar with notation, it seemed important to consider the
possibility that some participants might be unfamiliar with theory, or had limited notation skills. As an effective form of triangulation, it was important to obtain a melodic pattern audiation test that did not require any notation skills.

The same-different test design was also an important criterion for selecting a test. Of the many types and stages of audiation, all are based on the core principle of “concentrating on one set of musical sounds while at the same time attending to or performing one or more sets of other musical sounds” (Gordon, 2007:6). Several studies have suggested that performance on same-different tests requires musical working memory in order to hold one melodic pattern in mind and compare it when the second pattern arrives. In this sense same-different tests may be an effective measure of musical working memory. There is a strong inference running through the literature that musical working memory is amenable to training and can be enhanced through musical activities. Results on a same-different test should indicate some measure of musical working memory development.

The MET is similar in design to the AMMA but differs in several important features. While the AMMA combines rhythm and melody tests, the MET is designed with separate rhythm and melody tests. As Wallentin et al (2010) acknowledge, the design feature may impact on the ecological validity of the test, by separating melody and rhythm. This may be compensated, however, by a reduced risk of attentional ambiguity that may be present in the AMMA where attending to either rhythm or melody may impact the results. This design feature was particularly appropriate for the present study which focuses on tonal aspects of audiation. Because of this, only the melodic section of the MET was used in this present study. Therefore from here on, the term MET refers to only the melodic section of the test.

Some advantages of the MET are that it is relatively current (2010); readily available; easily administered to either individuals or large groups; it is also relatively short as the melodic section of the test takes about 10 minutes, which suited the duration requirements of the present study. Some ecological validity is demonstrated as the sounds used for the patterns are a realistic piano sound and the audio quality is high.

Validity and reliability of the test had been established in three experiments by Wallentin, et al (2010). Results showed the MET to be reliable in assessing musical aural competence in the normal adult population with a minimum of floor and ceiling effects even among highly skilled musicians and those without any musical background (Wallentin et al., 2010). In the experiments the MET clearly distinguished between small groups of professional-, amateur- and non-musicians; results were correlated with results on another music ability test and also with amount of musical practice (See Wallentin, et al. 2010). The MET also displays a high internal consistency. The whole test Cronbach alpha was found to be 0.85; and for the melody subtest: 0.82.
Music Transcription Task (MTT)

As indicated in chapter two, tonal understanding was defined as a three step sequential process that allows a listener to audiate heard or imagined tonal music and to infer a tonal centre, perceive the melodic contour and identify scale degrees. For a person literate with notation, tonal understanding also includes the ability to read notation and to hear it internally and audiate a tonal centre, the melodic contour and identify scale degrees. In order to evaluate this skill it was necessary to select a suitable test.

To measure tonal understanding a music transcription task (MTT) was selected. As discussed in chapter 4, the selection process focused on aspects of content validity: the suitability of the test item for tertiary music students and the accuracy with which the test measured tonal understanding in musicians. This was established by a detailed examination of publications in the area, by interview and discussions with five university music educators and pilot studies on item selection with 12 participants.

Final Form Of Music Transcription Task
The music transcription task from the 2001 HSC Examination is an excerpt from “Six Ceylan Songs” composed by Michael Nyman (1990). It demonstrated numerous qualities that suggested it would be advantageous for this study. They are as follows:

Low prior exposure
The 2001 date of the original examination minimized the likelihood of any prior-exposure effect. This was minimized even further by the relatively obscure nature of the composition used.

Ecological validity
This was strongly supported as the excerpt was created by a recognized and highly regarded composer. It is played by distinguished performers, on first-rate instruments and is professionally recorded for commercial purposes.

Voice
The melody to be transcribed is sung by soprano voice. The timbre of the human voice is a human universal and this neutral aspect of the stimulus had the potential to limit bias towards particular instrument timbres.

Foreign lyrics
The lyrics of the voice part are in German. The non-English nature of the voice part had the potential to direct attention to the melodic aspects of the task, rather than distracting, and potentially confounding, with verbal information.
Extractive listening

The voice part is accompanied by string orchestra. This brings to the task the important aspect of extractive listening. Listeners are required to isolate the voice from the surrounding string accompaniment.

Tonal ambiguity

The melody is purely diatonic, but the accompaniment is tonally ambiguous, moving between major and relative minor tonal centres. This tests listeners’ skills in inferring tonic which Karpinski (2000:84) describes as an important step in tonal understanding. This aspect of the task is supported by the absence of a key signature in the test sheet, an important consideration in a well-designed transcription task (Karpinski, 2000: 94).

Rhythm given

The design of this transcription task is relatively unusual because the rhythm of the melody is notated above the stave. This was particularly appropriate for the purposes of this study, which was limited to investigating tonal aspects of musical understanding. The pre-existing rhythm notation removed the need to divert attention to the rhythmic aspects, and allowed full attention to be focused on tonal aspects of the task. This potentially enhanced the task as a measure of tonal understanding reducing the potentially confounding element of rhythm.

Marking rubric

Included in the examination report for this transcription task, was the exact assessment rubric that was used for marking the 2001 Year 12 student responses. This provided an important framework from which to assess the results from this present study.

Duration

The task was 10 minutes which was ideal for this study.

MTT Design

The MTT had been designed through a rigorous vetting process involving numerous experts from the fields of music performance and education. It was designed specifically for measuring music transcription skills of music students at Year 12, the end of their secondary school music training.

In the course of developing and administering the MTT, it seemed that a potentially valuable way of adding a context to this present study’s results would be to compare them with the original results of the Year 12 students who completed the examination in NSW in 2001. Following a lengthy and complex process the results of the original 2001 HSC examination were obtained. This involved firstly numerous phone calls and emails to the BOS to find out if the original data existed.
A search of the BOS archives confirmed that the data still existed but approval by the BOS was required to access the data. The application process included supplying a full outline of the study, proof of ethical approval from the researcher’s institution, a letter of support from the principal supervisor and guarantee of confidentiality of the data. After a four month process the original results data in the form of a frequency distribution table was obtained via email.

The original audio file of the 2001 HSC exam was available on the BOS website. This was downloaded. This audio copy comprised the original verbal instructions and a single playing of the excerpt. In the original test, however, the audio was played six times. There was a designated pause after each playing as follows:

- First 10 second pause
- Second 30 second pause
- Third 1 minute pause
- Fourth 1 minute pause
- Fifth 2 minute pause
- Sixth 2 minute pause

Therefore to streamline the testing procedure so that a minimum of intervention was required it was necessary to recreate this exact format in a single audio file. To achieve this the audio file of the single playing was entered into Garage Band and copied it so that it repeated six times. To recreate the pauses, silences were entered in between each playing in the exact timed format as specified in the written instructions on the original exam sheet. To signal the start of each new playing a bell sound was inserted at the end of each pause.

**Limiting Practice Effects**

The original audio file began with spoken instructions for the test. This included information identifying the composer and name of the piece. Throughout the development of this study, a priority was to limit the possibility of practice effects. This meant limiting as far as possible, any identifying information about the tests leaking out to potential participants who might find the tests on the internet and practice them. In order to limit this possibility, the transcription task audio was de-identified by removing the spoken information about the origin of the excerpt. This left only the spoken instructions for the test procedure.

The blank test sheet also contained information identifying the origin of the excerpt. This information was removed from the test sheet, including the headers and footers of the document leaving only the written instructions. The rest of the test sheet was identical to the original. The modified test sheet used in the study is shown in Appendix 5.
**Procedure**

All testing sessions were conducted at the participating institutions. These sessions were arranged by contacting the relevant lecturer by telephone or email to schedule a mutually convenient time to conduct the tests.

In several cases where it was not possible for the researcher to participate at all in the testing session, the co-operation of the responsible lecturer was obtained to supervise the testing session. In these cases the sequence of the testing procedure was explained carefully in writing. This involved introducing the tests in the correct order, distributing and collecting the forms and playing two audio files. The test supervision process was also greatly simplified for the relevant lecturers and participants by clear written instructions on both the blank test sheets and also spoken instructions on both audio files. In all of the cases where the researcher could not be present, copies of all documentation and the two audio files were emailed.

Throughout the data collection period care was taken to keep details of the MTT and the MET confidential in order to limit the possibility that word might spread to other potential participants who could then practise for the test. This included sending the audio files to lecturers at the last possible moment. The blank sheets were also de-identified making recognition of the test material unlikely, and reducing the potential for practice effects. In the cases where I was not present at testing I also emphasized to the relevant lecturer the importance of confidentiality of the test materials for the study and asked that they not distribute the audio files or blank sheets to colleagues or other institutions until the data collection phase was finished.

In cases where the researcher was not present at testing session, to retrieve the filled-in test sheets, a prepaid, and registered, postage bag was sent to the relevant lecturer for return to the researcher.

**Procedure For The Individual Sessions**

The format for each individual session was standardized as follows:

1. Access the room designated for the testing and set up the equipment
2. Explanation to students about the study and the data collection. What would be required and how long it would take and requesting participation by the students. This included distribution of plain language statement.
3. Formal request for student participation. Those participating remain seated. Those not participating leave the room.
4. Distribution of consent forms for signing, and collect.
5. Distribution of three test forms stapled together: MBQ, MET and MTT
6. Instruction to spend five minutes filling in the MBQ as accurately as possible, using a codename in the space provided.

7. When everyone had filled in the MBQ, explanation of the MET test.

8. Completion of the MET according to verbal instructions included on the test recording.

9. Brief pause (two minutes) before starting the MTT. During this pause explanation of the MTT and instructions for completing the test.

10. Completion of MTT according to the verbal instructions on the test recording.

11. On completion of the testing the completed MBQ, MET and MTT were collected. Participants were thanked for their participation.

**Equipment Used During Testing**

Data collection sessions were held in a room normally assigned for the class group. This variation in testing sites meant it was not possible to control for all variables such as room acoustics. Although care was taken to ensure that each site remained as quiet and free of distraction as possible, the varying nature of the locations meant it was not possible to control for ambient noise interference and distractions. In the testing sessions observed by the researcher there was minimal distraction or interference from ambient noise.

At each testing site the in-house sound system was used to play the audio files. The variation in testing sites meant it was not possible to control for audio quality for each session. At those sessions attended by the researcher, the audio files were stored as mp3s on a MacBook Pro laptop. These were played by connecting to the in house sound system. In those sessions where the researcher was not present, the relevant lecturer played the audio files on the in house audio system. In those systems observed by the researcher, the quality of the sound systems was excellent, as might be expected from a principal tertiary music institution.

Access to the groups of participants occurred sometimes at the beginning a class and sometimes at the end. This left very little time to control for seating arrangements and the potential for copying answers on the tests. To minimize copying, participants were asked to space themselves evenly from one another. Due to often cramped spaces in testing sites this was often not feasible. In order to discourage the potential for copying, it was stressed to the participants that the tests were not competitive and that it would be most helpful if participants could be as honest as possible in their responses. In all of the sessions observed by the researcher, participants appeared to remain very focused on their own tasks, without talking or looking at others’ responses.
**Data Preparation**

The data were entered into an Excel spreadsheet, with one row for each participant. All variables were then checked for data entry errors, and corrected as required. Logical checks were carried out, and any errors found were remedied.

Descriptive statistics were obtained on all variables, consisting of frequency distributions for categorical variables and summary measures for numerical variables. More details about coding of variables is provided in the context in which it arises, in the formal analysis of the data.

The key outcomes are the MET and the MTT. Initial examination of simple associations between explanatory variables and these outcomes were carried out, with explanatory variables coming from the survey filled out by the participants, including their years and type of musical training, previous and current. More formal inferences involved modelling the two outcomes using general linear models and logistic regression. These approaches are fully described in the Results chapter.

All analyses were done using Minitab versions 16 and 17.

**Conclusion**

This chapter reported on the various processes that led to the design of the study. This included the rationale for the study, and the various steps leading to the selection of the tests, as well as the design of the questionnaire. It also described the various stages of the data collection. Results for the two separate tests and background information were collected from 340 participants. The following two chapters report the analysis of results of the two tests.
CHAPTER 6: RESULTS/ANALYSIS: MELODIC PATTERN AUDIATION

In order to respond to the research questions detailed in the preceding chapter, this chapter reports on the results of the test for melodic pattern audiation as measured by the Musical Ear Test (MET). The results will be analyzed in relation to information gathered on participants’ background, including training and pre-existing factors. To assist in the analysis, results will also be analyzed in relation to the structural aspects of the individual MET melodies. The final part of the chapter deals with the development of a model to predict melodic pattern audiation in trained musicians. The chapter begins with some basic brief information about the sample data obtained, to give some relevant background to the more substantive analyses of results in the following two chapters.

Description of the Participants

Response rates
Of the 22 institutions approached, 14 agreed to participate. This is a response rate of 64% at the institutional level. In the class groups approached 635 individuals were enrolled. Of these, 340 individuals agreed to participate. This is a response rate of 53.5% at the individual level. Individual response rates within class groups varied from 4/32 (12.5%) to 31/34 (91%).

This number of participants was adequate for reasonably precise estimation of the regression coefficients in the general linear models, and for testing of effects with sufficient statistical power.

Sample Characteristics
There were 156 females, 173 males. (11 gave no response). Ages ranged from 16 to 56 with an average of 22 years. 8% reported they had perfect pitch. Related to this, 7% reported they spoke an Asian language. Participants reported themselves to be primarily either classical musicians, popular musicians (pop, rock, blues and jazz) or a mixture. Table 2 shows a relatively even distribution of types of musicians.

Participants reported their principal instrument. These were grouped into their instrument families. Bass guitar was included with guitar, while double-bass was included with strings. Drum-kit was included with percussion. Keyboard included piano and organ. Table 3 shows a relatively even distribution of instrument types in the sample.

<table>
<thead>
<tr>
<th>Type</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classical</td>
<td>144</td>
<td>42</td>
</tr>
<tr>
<td>Popular</td>
<td>119</td>
<td>35</td>
</tr>
<tr>
<td>Mixture</td>
<td>77</td>
<td>23</td>
</tr>
</tbody>
</table>

   340 100
CHAPTER 6: RESULTS/ANALYSIS: MELODIC PATTERN AUDIATION

Table 3: Principal Instrument Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brass</td>
<td>29</td>
<td>9</td>
</tr>
<tr>
<td>Guitar</td>
<td>61</td>
<td>18</td>
</tr>
<tr>
<td>Keyboard</td>
<td>72</td>
<td>21</td>
</tr>
<tr>
<td>Percussion</td>
<td>35</td>
<td>10</td>
</tr>
<tr>
<td>Strings</td>
<td>41</td>
<td>12</td>
</tr>
<tr>
<td>Voice</td>
<td>54</td>
<td>16</td>
</tr>
<tr>
<td>Woodwind</td>
<td>48</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>340</td>
<td>100</td>
</tr>
</tbody>
</table>

Some general training characteristics of the sample are given in Table 4.

Table 4: Participant Training

<table>
<thead>
<tr>
<th>Age at start of learning</th>
<th>Average 11 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years playing</td>
<td>Average 11 years</td>
</tr>
<tr>
<td>Tuition</td>
<td>97%</td>
</tr>
<tr>
<td>Exam at Grade 6 or higher</td>
<td>43%</td>
</tr>
<tr>
<td>Year 12 music</td>
<td>80% (6 no response)</td>
</tr>
<tr>
<td>BMus</td>
<td>92% (completed or completing)</td>
</tr>
</tbody>
</table>

Almost two-thirds of participants (205 or 60%) said they had completed formal examinations on their main instrument. Of these, 196 identified a music examination organization. These nominated examination organizations are shown in Table 5.

Table 5: Exam Organizations Named By Participants

<table>
<thead>
<tr>
<th>Examination Organization</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australian Music Examinations Board (AMEB)</td>
<td>165</td>
<td>84</td>
</tr>
<tr>
<td>Associated Board of the Royal Schools of Music (ABRSM)</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td>Trinity College London</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Australian and New Zealand Cultural Arts (ANZCA)</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>London College of Music (LCM)</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>International Music Examinations Board (IMEB)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>196</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 6: Frequencies in Combinations: Gender, Learning, Language, Music Type, Perfect Pitch

<table>
<thead>
<tr>
<th>Main Way of Learning</th>
<th>Gender</th>
<th>Language</th>
<th>Classical</th>
<th>Mixture</th>
<th>Popular</th>
<th>Classical</th>
<th>Mixture</th>
<th>Popular</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Asian</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other</td>
<td>30</td>
<td>14</td>
<td>8</td>
<td>5</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Asian</td>
<td>7</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other</td>
<td>54</td>
<td>2</td>
<td>2</td>
<td>15</td>
<td>15</td>
<td>17</td>
</tr>
<tr>
<td>Combination</td>
<td>Male</td>
<td>Asian</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other</td>
<td>5</td>
<td>20</td>
<td>48</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Asian</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other</td>
<td>3</td>
<td>1</td>
<td>15</td>
<td>15</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Ear</td>
<td>Male</td>
<td>Asian</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Asian</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other</td>
<td>2</td>
<td>1</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
For reasons related to subsequent modelling, it is of interest to look at some combinations of variables. Table 6 shows the numbers in all combinations of the five variables: gender, language and perfect pitch; and main way of learning (by ear, by notation, or by a combination of both) and type of music played (classical, popular, or a mixture of both).

For example, the bottom left-hand corner of Table 6, shows that in this sample, there was only one person with perfect pitch who learned by ear, and this person was a female, Asian-speaking, classical musician.

Among other things, the table shows that there are many combinations in this finely grained cross-tabulation that are not represented in the sample. One area that is markedly under represented is in main way of learning, where only 12% of participants learned mainly by ear.

**MET Design**

There are 52 items in the MET. Each item is a pair of short melodic phrases played consecutively. Participants listen to the pair of phrases and judge whether they are identical or not. Answers are marked in one of two boxes on a response sheet (See Appendix 6). The sound of the melodic patterns is a high quality sampled grand piano. Each melodic pattern has a duration of one bar. The rhythm of each melody is simple, consisting of half notes, quarter notes and eighth notes. The melodies are accompanied by a steady metronome pulse at a lower volume, because the authors considered this desirable to avoid rhythm perception interfering with melodic perception. The tempo of 100 bpm was considered to be close to people’s preferred tempo (Wallentin, email communication, 2011). According to the authors of the MET floor and ceiling effects were minimized by use of melodic patterns that encompass a wide span of difficulty. This difficulty level was increased by adding non-diatonic notes and contour violations. (Wallentin, email communication, 2011).

**MET Pattern Structural Characteristics**

The 52 pairs of MET melodic patterns have the following structural characteristics.

- Between three and eight tones.
- Major (20), Minor (7), Atonal (25).
- Same (26), Different (26).

The “different” trials differ only melodically, not rhythmically, and contain one pitch violation. For half of these (13 trials), the pitch violation also constitutes a contour violation. The order of occurrence of all of the above features is randomized, and therefore so is the difficulty level.
CHAPTER 6: RESULTS/ANALYSIS: MELODIC PATTERN AUDIATION

MET Procedure

The MET was introduced by advising participants that they would hear pairs of short melodies. The task was to decide if the two melodies were identical or not. If they were identical they should tick the box marked “yes”, if they were not identical, they should tick the box marked “no”. It was also explained that the test was accompanied by a steady metronome beat and once the test began there would be little time between each pair to make a decision before the next pair began. The test would take about 10 minutes. There would be two example questions before the main test which would help explain what was required.

After this explanation participants were asked if there were any questions and then if everybody was ready the audio file was played. The beginning of the audio also includes spoken instructions as follows:

Examples. You will now hear an example of two short melodic phrases played immediately after one another. You must decide whether the phrases are identical. If they are identical you should answer yes. If they are not identical you should answer no. Here is the first phrase [melody is heard]. And here is the second phrase [second melody].

The examples were followed by a spoken explanation of whether they were same or different. After the two sample trials participants were asked whether there were any questions or problems with the sound. If everybody was satisfied the test was started. The audio began with the following spoken introduction:

The test. Now you are about to do the test. There are a total of 52 numbered questions beginning with question number 1.

This was followed a spoken count-in “1,2,3,4” and then the first item was heard. Before each item, a sequential identifying number was announced.

MET Scoring

Scoring of the MET occurred immediately after each testing session. The MET comes with a set of correct answers in the form of a test sheet with crosses marked in all the correct boxes. In order to simplify the scoring process as well as to assist in the correct recording of all responses, a transparency of the correct answer sheet was created. This was used to overlay each participant’s completed test sheet. On the transparency the correct boxes were filled in. When overlayed on a participant result sheet, only the incorrect answers were visible. These were counted up and deducted from the total of 52 to arrive at the score. An Excel spreadsheet was created with the codename of the participant as well as an identification number. The MET score was entered next to this.
In order to verify the scoring process, in addition to the transparency method, a secondary scoring method was devised. For every participant test sheet, the result on each individual item was also recorded. This meant recording 52 separate results for 340 participants, a total of $340 \times 52$ 17,680 entries. To facilitate this task a data entry template was devised. An abbreviated version of the data entry template, using only one participant is shown in Table 7.

An MSWord document was set up with a column for identifying the number of each participant and 52 columns for the result of each item. Each participant’s response to each individual item was recorded in a binary system: 1 for “yes” 2 for “no”. Once all the participants results were entered, the correct MET answers were also entered. Note that for participant 1, the sole incorrect response was item 26, shown in bold.

### Table 7. MET Data Entry Template

<table>
<thead>
<tr>
<th>MET Item number /52:</th>
<th>1234567890123 4567890123456 7890123456789 0123456789012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct MET answers:</td>
<td>2112211221121 1121212222222 11211111212112 1212122211221</td>
</tr>
<tr>
<td>Participant 1 answers:</td>
<td>2112211221121 1121212222221 11211111212112 1212122211221</td>
</tr>
</tbody>
</table>

(1=Yes, 2=No)

This data was then transferred from the Word document and recorded in the Excel spreadsheet and each individual item was recorded as either correct (1) or incorrect (0). These individual results were then cross checked against the MET correct answers giving a result out of 52. This Excel generated score was then cross checked with the score that had been derived by hand using the transparency method.

Processing the data this way proved important. Using this cross-checking method, a fault was identified in the transparency scoring approach. The filled in boxes on the transparency had failed to detect when participants had left a box blank. This meant that blank items had been marked as correct but in fact should have been marked incorrect. These anomalies were rectified and both sets of scores matched for every participant. The following section reports on the results of the MET.

### MET Results

The results for the total sample ($n = 340$) on the MET showed a mean of 84% of items correctly answered, or 44 items out of 52. (sd = 4.3), and a range of 25 to 52. To assist in the analysis of the MET results, for the purposes of general comparison, the results of this present study are compared here with the results of the original MET study in Denmark (Wallentin, et al. 2010).
The Danish study used the MET to test non-musicians, amateur musicians and professionals. Those results are shown in Table 8. Note that much smaller sample sizes were used.

Table 8: MET Danish Results

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Non-musician</th>
<th>Popular</th>
<th>Amateur</th>
<th>Professional</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>70% (n = 20)</td>
<td>87% (n = 20)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>67% (n = 5)</td>
<td></td>
<td>89% (n = 16)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>67% (n = 21)</td>
<td>79% (n = 21)</td>
<td>89% (n = 18)</td>
<td></td>
</tr>
</tbody>
</table>

(Wallentin et al, 2010)

As shown in Table 8, mean scores in the Danish study ranged from 89% (46/52 questions) for professional musicians, 79% (41/52 questions) for amateur musicians and 67% (35/52 questions) for non-musicians. Figure 2 positions the Australian tertiary results 84% (44/52 questions) among the Danish non-musician, amateur, popular and professional results. In the present Australian tertiary study, only 12 participants (4%) scored at or below the level of non-musicians in Danish study (67%). This means that the Australian tertiary participants performed in general better than the Danish non-musicians, and better than the Danish amateur musicians. The average scores of the Australian tertiary group (84%) were slightly under those of the Danish popular musicians (87%) and Danish professionals (89%). These results suggest some differences between groups in difficulty of audiating the MET melodic patterns.

Figure 2: MET % Results Danish Versus Australian
CHAPTER 6: RESULTS/ANALYSIS: MELODIC PATTERN AUDIATION

Melodic Pattern Structural Factors

In the present study there was a distinct hierarchy of difficulty among the 52 MET items, with some melodic patterns more easily audiated than others. The graph in Figure 3 shows, for each of the 52 MET items, the percentage of the total sample who answered correctly. The easiest item was number 21 which was correctly audiated by 100% of participants. The most difficult pattern to audiate was item 26. Almost three quarters of participants were unable to audiate it correctly.

% Correct in Increasing Order
(Data labels are the item numbers)

![Figure 3: MET Hierarchy of Difficulty](image)

![Figure 4: MET Easiest Item 21](image)

![Figure 5: MET Hardest Item 26](image)
In order to investigate which structural aspects of melodic patterns add to audiation difficulty, the melody of each individual MET item was analyzed and compared with the results for each individual item. For example, the easiest item 21 (Figure 4) is in major tonality and contains a pitch violation which is also a contour violation. The most difficult item 26 (Figure 5) is atonal and contains a pitch violation without a contour violation. (Arrows indicate the alteration). Item 21 has a typical progression with small intervals; item 26 has a larger range and larger intervals.

**Sameness, Difference And Tonality**

The MET results were analyzed in relation to the structural features of the individual patterns. Figure 6 shows for each of the 52 MET items, the percentage of the total sample who answered correctly. These results are then grouped according to the structure of each item: major, minor or atonal, and whether the pattern is same or different.

![Figure 6: MET % Correct By Same/Different and Tonality](image)

Figure 6 shows that the same-different comparison varies notably with tonality. If an item has a predictable musical context of major or minor tonality there is little difference in performance regardless of whether a pair is same or different. The more unpredictable atonal pairs are much harder to audiate. It is only for these atonal patterns that same items are audiated more easily than the different items.
CHAPTER 6: RESULTS/ANALYSIS: MELODIC PATTERN AUDIATION

**Type of Pattern Alteration**
Audiation difficulty is also associated with the type of difference in a pair of melodies. Figure 7 analyzes the results of the 52 items to see how the tonality and type of alteration of each pattern affected the difficulty level. (The numbers represent the item number). The “Pitch” column shows pairs that were different because of a pitch change only. The “Contour” column shows pairs that were different in both pitch and contour.

% Correct by Tonality and Alteration  
(means shown by blue squares)

![Figure 7: MET % Correct By Tonality and Alteration](image)

In Figure 7 the right hand columns (“Contour”) show that a change in contour made patterns easiest to audiate. Almost all participants were able to correctly audiate when a pattern changed in contour regardless of whether the pattern was major, minor or atonal. The left hand columns (“None”) show that same items were slightly harder to audiate if they were atonal. The centre columns (“Pitch”) show that by far the hardest melody pairs to audiate were atonal different pairs with a pitch alteration.
Number of Tones

The analysis of individual MET patterns included number of tones. Figure 8 shows the results of the individual MET items organized into nine categories of alteration and tonality. The red circles indicate for each item the percentage of the total sample that correctly answered. The items in each category are organized from left to right according to the number of tones they contain (3-8). The dotted lines represent the general linear trend between % correct and number of tones. The general downward slant left to right of the lines suggests an effect of the number of notes: the more notes in a pattern, the more difficult it is to audiate.

Panel variables: Alteration, Tonality

Figure 8: MET % Correct Versus Number of Tones, Tonality and Alteration
**Item Number**

Figure 9 examines the results in relation to their place in the order of 52 items. It examines this in relation to two other variables: pattern tonality, and type of alteration.

The generally flat lines in Figure 9 suggest there is no strong effect of item order on the MET. An analysis of the order of the items, along with their tonality and alteration suggested that fatigue did not have any significant effect on performance on the items.

**Summary of MET Pattern Structural Factors**

The preceding analyses revealed a clear hierarchy of difficulty in audiating the MET melodic patterns. Some patterns were more difficult to audiate than others. This difficulty level was not random, but was associated with certain structural aspects of the melodies. The easiest patterns to audiate were same patterns in a predictable major key. By far the most difficult to audiate were unpredictable atonal patterns with a pitch alteration. The more notes in a pattern the harder they were to audiate, possibly suggesting a result of limitations of musical working memory. Item order did not appear to impact pattern audiation difficulty, suggesting difficulty was not related to fatigue or loss of concentration towards the end of the test.
CHAPTER 6: RESULTS/ANALYSIS: MELODIC PATTERN AUDIATION

The preceding analyses showed some melodic pattern tasks require more highly developed audiation than others and that some musicians were better than others to audiate the more difficult melodic patterns. The next section of the analysis examines results on the MET in relation to training factors that may be associated with enhanced ability to audiate melodic patterns.

MET and Musical Training

The distinct hierarchy of difficulty in the results on the MET showed that certain musicians are better equipped than others at audiating melodic patterns despite complex structural elements involved. An aim of this study is to determine which factors contribute to this enhanced melodic pattern audiation ability. To investigate this, results on the MET were considered in relation to variables obtained from the musical background questionnaire. These training variables were organized into two categories as follows.

**Type of training:**
- type of music played; way of learning; instrument played; teaching method used.

**Extent of training:**
- years since starting; level of examinations; secondary and tertiary training

Some of these variables are categorical (e.g. instrument category), and some are numerical (e.g. years since started musical training). For each potential explanatory variable, separate analyses were carried out. For categorical variables this was either a two-sample t-test or a one-way analysis of variance, while for numerical variables the correlation was calculated. Also, for each variable separately, an appropriate graph was obtained: for categorical variables, an “individual value plot” showing group means, and for numerical variables, a scatterplot.
Type of Training

Type Of Music Played

Almost half the participants (42%) reported themselves as mainly classical musicians, about one third were popular musicians (35%), and the remainder played a mixture of music. Figure 10 shows each participant’s total score out of 52 grouped according to the type of music they mainly played.

![Graph showing MET Versus Type of Music Played](image)

*Means shown by solid black squares*

Figure 10: MET Versus Type of Music Played

Descriptive statistics and one way ANOVA

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>F statistic</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classical</td>
<td>144</td>
<td>43.70</td>
<td>3.92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Popular</td>
<td>119</td>
<td>43.24</td>
<td>4.36</td>
<td>2.76</td>
<td>0.065</td>
</tr>
<tr>
<td>Mixture</td>
<td>77</td>
<td>44.69</td>
<td>4.64</td>
<td>df = 2.337</td>
<td></td>
</tr>
</tbody>
</table>

The results of the MET showed no significant difference between groups of musicians. Popular musicians scored very slightly lower (mean 43/52) than the classical musicians (mean 44/52). Those who played a mixture of musics scored slightly better by one MET item (mean 45/52). No significant difference is indicated here between classical and popular musicians, or those who play a mixture of musics, in their ability to audiate melodic patterns.
Way Of Learning

A further point of investigation was whether differences in melodic pattern audiation may be related to the way musicians learn. Table 9 shows that almost half the participants learned mainly by notation, and almost half learned by a combination of notation and ear. Only a relatively small proportion (12%) said they learned mainly by ear.

Table 9: Main Way of Learning

<table>
<thead>
<tr>
<th>Way of learning</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notation</td>
<td>153</td>
<td>45</td>
</tr>
<tr>
<td>By ear</td>
<td>42</td>
<td>12</td>
</tr>
<tr>
<td>Combination</td>
<td>145</td>
<td>43</td>
</tr>
<tr>
<td>Total</td>
<td>340</td>
<td>100</td>
</tr>
</tbody>
</table>

Individual scores on the MET were analyzed according to the way a participant learned. Figure 11 shows the score out of 52 and grouped according to type of learning.

Figure 11: MET By Main Way of Learning

Descriptive statistics and one way ANOVA

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>F statistic</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notation</td>
<td>153</td>
<td>43.71</td>
<td>3.96</td>
<td>0.27</td>
<td>0.765</td>
</tr>
<tr>
<td>Ear</td>
<td>42</td>
<td>44.21</td>
<td>4.25</td>
<td>df = 2,337</td>
<td></td>
</tr>
<tr>
<td>Mixture</td>
<td>145</td>
<td>43.69</td>
<td>4.60</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Mean results on the MET were virtually identical for all three groups: 44/52 questions. This suggests that a musician’s mode of learning had no significant effect on their ability to audiate melodic patterns.

**Teaching Method**

Almost all participants (97%) said they had received lessons on their principal instrument. Only six said they did not. Three did not respond to this question. Of those who had lessons, 47 people nominated a specific method of instrumental music teaching. On the questionnaire this was termed “school of teaching”. Table 10 shows the distribution of named methods.

<table>
<thead>
<tr>
<th>Method</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estill</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Kodaly</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Suzuki</td>
<td>24</td>
<td>7</td>
</tr>
<tr>
<td>Suzuki/Kodaly</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Suzuki/Yamaha</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Yamaha</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Young Chang</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>None</td>
<td>293</td>
<td>86</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>340</td>
<td>100</td>
</tr>
</tbody>
</table>

![Figure 12: MET By School or Not](image)

Means shown by solid black squares

Descriptive statistics and a two-sample t-test for school of teaching. (“Yes” minus “No”)

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Diff. of means</th>
<th>95% CI</th>
<th>T-statistic</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>293</td>
<td>43.74</td>
<td>4.38</td>
<td>0.13</td>
<td>-1.19, 1.45</td>
<td>0.19, df = 338</td>
<td>0.849</td>
</tr>
<tr>
<td>Yes</td>
<td>27</td>
<td>43.87</td>
<td>3.51</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Participants were divided into two groups, those who mentioned a teaching method, and those who did not, since the numbers were too small for a more detailed analysis. Figure 12 compares MET results of those who had learned using a particular school of teaching (“Yes”) and those who had not (“No”). No significant difference was found in melodic pattern audiation ability between those who learned by a particular teaching method and those who did not.

**Type Of Instrument**
Participants were asked to name their principal instrument. Table 4 shown earlier indicated a relatively even distribution of instrumental groups. Figure 13 shows the results on the MET grouped into these instrumental families.

![Figure 13: MET By Instrument Category](image)

Means shown by solid black squares

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>F statistic</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brass</td>
<td>29</td>
<td>44.52</td>
<td>3.68</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guitar</td>
<td>61</td>
<td>43.56</td>
<td>4.83</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Keyboard</td>
<td>72</td>
<td>43.69</td>
<td>4.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percussion</td>
<td>35</td>
<td>43.40</td>
<td>4.35</td>
<td>0.44</td>
<td>0.855</td>
</tr>
<tr>
<td>Strings</td>
<td>41</td>
<td>44.15</td>
<td>3.49</td>
<td>df = 6,333</td>
<td></td>
</tr>
<tr>
<td>Voice</td>
<td>54</td>
<td>43.30</td>
<td>4.84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Woodwind</td>
<td>48</td>
<td>44.13</td>
<td>3.91</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There was no significant effect on the MET for any instrument category, suggesting that melodic pattern audiation is not enhanced by learning any particular instrument.
CHAPTER 6: RESULTS/ANALYSIS: MELODIC PATTERN AUDIATION

Extent Of Training

The following section extends the analysis of training factors by examining results on the MET in relation to the extent of a musician’s training. Information gathered on the extent of training variables included: number of years since the start of training, examination level achieved, training at secondary school, and tertiary level training.

Years Since Start Of Training

Figure 14 shows the results on the MET in relation to years since a participant started their musical training.

![Figure 14: MET Versus Years Since Start of Training](image)

The correlation between the MET and Years since start of training was $r = 0.03$ ($P = 0.563$) suggesting that the amount of time a person has spent learning an instrument was not significantly associated with their ability to audiate melodic patterns.
Examination Level

For the purposes of this study, the level of a Grade 6 instrumental examination represents a notional indicator of instrumental training equivalent to the end of secondary schooling. Grades achieved beyond this level represent tertiary level instrumental training. Almost half of the total participants (43%) had completed an instrumental music examination of Grade 6 or higher. Figure 15 compares the results of the MET between those who had achieved an examination level of grade 6 or higher and those who had not.

![Figure 15: MET By Exam at Grade 6 or Higher](image)

Means shown by solid black squares

Descriptive statistics and two-sample t-test comparison (“Yes” minus “No”):

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Diff. of means</th>
<th>95% CI</th>
<th>T-statistic</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>193</td>
<td>43.35</td>
<td>4.46</td>
<td>0.95</td>
<td>0.03, 1.86</td>
<td>2.04, df = 338</td>
<td>0.043</td>
</tr>
<tr>
<td>Yes</td>
<td>147</td>
<td>44.30</td>
<td>3.96</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There is a small advantage (one MET item) to those who have completed an exam of Grade 6 or higher on their main instrument.
Secondary Training

271 participants (80%) reported that they had studied music as a Year 12 subject. Figure 16 compares the results on the MET between those who had completed music as a subject in Year 12 and those who had not. The six participants who did not provide an answer for the question are excluded here.

![Figure 16. MET By Year 12 music](image)

Means shown by solid black squares

Descriptive statistics and two-sample t-test comparison (“Yes” minus “No”):

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Diff. of means</th>
<th>95% CI</th>
<th>t-statistic</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>63</td>
<td>43.95</td>
<td>4.98</td>
<td>-0.22</td>
<td>-1.39, 0.96</td>
<td>-0.37, df = 332</td>
<td>0.715</td>
</tr>
<tr>
<td>Yes</td>
<td>271</td>
<td>43.73</td>
<td>4.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There was no difference in results on the MET whether participants studied music at secondary school or not. Results slightly favored those who did not study music at secondary school: a mean score of 43.95 as compared to 43.73 for those who had. Formal training on an instrument as a subject in Year 12 showed no effect on the ability to audiate melodic patterns.
Tertiary Training

Almost all of the participants (92%) were completing tertiary level music training in the form of a Bachelor of Music (BMus). Many had already completed a BMus and some held additional degrees in instrumental music performance. Figure 17 compares results on the MET between those who were enrolled in or had completed a BMus with those who were not.

![Figure 17: MET By BMus](image)

*Means shown by solid black squares*

Descriptive statistics and two-sample t-test comparison (“Yes” minus “No”):

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Diff. of means</th>
<th>95% CI</th>
<th>t-statistic</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>27</td>
<td>44.07</td>
<td>4.19</td>
<td>-0.34</td>
<td>-2.03, 1.35</td>
<td>-0.40, df = 338</td>
<td>0.693</td>
</tr>
<tr>
<td>Yes</td>
<td>313</td>
<td>43.74</td>
<td>4.28</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As observed with the secondary school results, there was a very slight advantage towards those who had not studied towards a BMus, a mean score of 44.07 as compared to 43.74 for those completing or having completed a BMus. Enrolment in, or completion of, a Bachelor of Music course shows no significant effect on melodic pattern audiation.
CHAPTER 6: RESULTS/ANALYSIS: MELODIC PATTERN AUDIATION

MET and Pre-existing Factors

The next phase of the analysis involved examining non-training factors that may be associated with melodic pattern audiation.

Gender

There were 156 female and 173 male participants. 11 others did not provide their gender and were not used in the analysis of this variable. Figure 18 shows the MET results comparing males and females.

Descriptive statistics and two-sample t-test comparison (male minus female).

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Diff. of means</th>
<th>95% CI</th>
<th>t statistic</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>156</td>
<td>43.29</td>
<td>4.14</td>
<td>0.86</td>
<td>-0.06, 1.79</td>
<td>1.84, df = 327</td>
<td>0.067</td>
</tr>
<tr>
<td>Male</td>
<td>173</td>
<td>44.15</td>
<td>4.34</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A slight advantage was found for males in melodic pattern audiation. The advantage of approximately one MET item is not significant when considered individually. In further modelling, however, gender became an important variable in predicting melodic pattern audiation in musicians.
Perfect Pitch

Twenty-five participants answered yes to the question “Do you have perfect pitch?”. Time and logistical constraints at the testing sites did not allow verification of these self-reports. Two participants, instead of ticking “Yes” or “No”, wrote “Sometimes”. These two participants were included in the “Yes” group in the following analysis. Six participants did not respond and were excluded here. Figure 19 shows the MET results comparing those with perfect pitch and those without.

Figure 19: MET By Perfect Pitch

Means shown by solid black squares

Descriptive statistics and two-sample t-test comparison (“Yes” minus “No”):

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Diff. of means</th>
<th>95% CI</th>
<th>t-statistic</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>307</td>
<td>43.51</td>
<td>4.17</td>
<td>2.12</td>
<td>0.45, 3.79</td>
<td>2.50, df = 332</td>
<td>0.013</td>
</tr>
<tr>
<td>Yes</td>
<td>27</td>
<td>45.63</td>
<td>4.84</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Musicians with perfect pitch showed a significantly better ability to audiate melodic patterns (mean 46/52) than those without (mean 44/52), an advantage of two MET items.
Possession of perfect pitch was the most significant factor in MET scores regardless of type of music played. This is shown in Figure 20 which analyzes MET results and perfect pitch in relation to the type of music played; note that there was only one “popular” musician who reported perfect pitch.

![Figure 20: MET By Perfect Pitch and Type of Music](image)

*Means shown by blue squares*

**Language And Perfect Pitch**

Background data was gathered on both perfect pitch and native language based on the supposition that there might be an association between a person’s language and their ability to audiate melodic patterns. The various languages reported in response to the question “What do you consider your native language?” were recoded into two language groups, Asian or European. This was partly because there were a number of languages reported by just one participant, which is not manageable analytically, and also because it was considered that the important distinction to be made is between tonal (Asian) and non-tonal (European) languages.
The languages counted as Asian were Cantonese (4), Farsi (1), Indonesian (3), Japanese (1), Korean (3) and Mandarin (13). The languages classified as European were Afrikaans (1), English (308), German (1), Italian (3), Polish (1) and Spanish (1). This gave 25 in the “Asian” category and 315 in the “European” group. Figure 21 shows the MET results comparing Asian language speakers with Europeans.

Descriptive statistics and two-sample t-test comparison (Asian minus European):

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Diff. of means</th>
<th>95% CI</th>
<th>t-statistic</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asian</td>
<td>25</td>
<td>44.68</td>
<td>3.02</td>
<td>0.99</td>
<td>-0.75, 2.74</td>
<td>1.12, df = 338</td>
<td>0.264</td>
</tr>
<tr>
<td>European</td>
<td>315</td>
<td>43.69</td>
<td>4.35</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 21 shows the MET results comparing Asian language speakers with Europeans. This small advantage may be attributable to the increased prevalence of perfect pitch in some Asian languages.

To examine this possibility, MET results were analyzed by comparing the incidence of perfect pitch (PP) in the Asian and European language groups. This is shown in Figure 22.
CHAPTER 6: RESULTS/ANALYSIS: MELODIC PATTERN AUDIATION

Figure 22 confirms that a higher proportion of the Asian language participants had perfect pitch compared with the European language group. The mean scores on the MET were also higher for the Asian language group.

![Figure 22: MET Individual Value Plot, Perfect Pitch and Language](image)

Participant Rating Of Aural Skills
Information was also gathered on participants’ perceptions of the value of audiation (“aural skills”) in becoming an excellent musician. Possible responses ranged from “not at all” to “highly”. No-one considered aural skills to be “not very” or “not at all” important. Most musicians (84%) placed a high importance on aural skills. 13% considered them the next highest value “moderately”. Only 3% considered aural skills to be “a little” important. Note that six subjects gave no response. Figure 23 analyzes results on the MET in relation to the value rating by participants.
Participants who gave a “little” rating to the value of aural skill scored much lower on the MET. High raters scored highest. The “little” group had a mean score of 40/52. This is three questions lower than the “moderate” group (43/52) and four questions lower than the “highly important” group (44/52).

![Figure 23: MET By Rating of Importance of Aural Skill](image)

**Means shown by solid black squares**

The final phase of the analysis of the MET involved determining to what extent melodic pattern audiation can be predicted from all of the training and pre-existing variables.
Melodic Pattern Audiation: Predictive Model

An important goal of this study was to determine what training and pre-existing factors might predict audiation in trained musicians. After the preceding univariate analyses (one explanatory variable per analysis) a process of obtaining a predictive model using several variables simultaneously was followed. Regression modelling assesses relationships between one dependent variable and a set of independent variables. The aim is to remove nonsignificant variables and determine the relative importance of significant variables retained in the equation. Multiple regression analysis was used to predict which of the variables identified in the study were important factors in melodic pattern audiation ability.

In the following section, standard multiple regression was used investigate effect sizes in each of the variables identified in the musical background questionnaire thought to be associated with audiation in musicians. The research question being addressed was the degree to which melodic pattern audiation could be predicted from a musician’s training and pre-existing traits.

All variables were included in a general linear model, and a backward stepwise procedure was used to successively remove variables until all remaining variables were statistically significant predictors at the 10% level. The same explanatory variables as shown above were considered, namely: Years of training; Gender; Language; Perfect Pitch; Instrument; Type of music played; Main way of learning; Method or not; Exam at Grade 6 or not; BMus; Year 12 music; Rating of aural skills.

Among the 340 subjects, there were missing values on some of these variables, as follows: Years since started musical training: 4; Gender: 11; Perfect Pitch: 6; Year 12 music: 6; Rating of aural skills: 6. In combination, there were 31 subjects (9.1%) with missing data on at least one of these variables.

Table 11: Backward Stepwise Procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Variable removed</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BMus: yes or no</td>
<td>0.973</td>
</tr>
<tr>
<td>2</td>
<td>Year 12 music</td>
<td>0.884</td>
</tr>
<tr>
<td>3</td>
<td>Pedagogy Method or not</td>
<td>0.809</td>
</tr>
<tr>
<td>4</td>
<td>Years since start of training</td>
<td>0.702</td>
</tr>
<tr>
<td>5</td>
<td>Instrument category</td>
<td>0.598</td>
</tr>
<tr>
<td>6</td>
<td>Type of music played</td>
<td>0.229</td>
</tr>
<tr>
<td>7</td>
<td>Main way of learning</td>
<td>0.314</td>
</tr>
<tr>
<td>8</td>
<td>Language group</td>
<td>0.156</td>
</tr>
<tr>
<td>9</td>
<td>Importance of aural skill</td>
<td>0.171</td>
</tr>
</tbody>
</table>
For the purposes of fitting a general linear model, listwise deletion was used, so that the model selection was carried out on the remaining 309 subjects. All variables were considered, and a backward stepwise procedure was used to successively remove variables until all remaining variables were statistically significant predictors at the 10% level. This resulted in a model with gender, perfect pitch and exam at Grade 6 or higher as the three variables remaining in the model. The variables removed, the step at which they were removed, and the corresponding P-values, are shown in Table 11.

After step 9, the remaining variables were statistically significant at the 10% level at least. These variables were:

- Perfect pitch (perfect pitch had higher MET scores)
- Gender (males had higher MET scores)
- Exam at grade 6 or higher (high level exam had higher MET scores).

This selected model used a data set with 309 observations, due to the requirements for complete data on all relevant variables. This regression analysis gives a predicted equation for the MET, according to an individual’s profile. The results of the analysis are expressed in Table 12.

Table 12: Estimated Effects for Regression of MET on Explanatory Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Level</th>
<th>Baseline</th>
<th>Difference</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>male</td>
<td>female</td>
<td>0.94</td>
<td>(0.00 to 1.89)</td>
<td>0.05</td>
</tr>
<tr>
<td>Perfect pitch</td>
<td>yes</td>
<td>no</td>
<td>1.65</td>
<td>(-0.13 to 3.42)</td>
<td>0.07</td>
</tr>
<tr>
<td>Exam grade &gt;6</td>
<td>yes</td>
<td>no</td>
<td>0.98</td>
<td>(0.00 to 1.96)</td>
<td>0.05</td>
</tr>
</tbody>
</table>

The regression coefficients express the strength of the association between the variable and the MET score, adjusted for the other variables in the model. For example, it is estimated that, on average, those with perfect pitch had a MET score 1.65 higher than those without perfect pitch, after adjustment for gender and exam grade six or greater.

Also shown in the table are the corresponding 95% confidence intervals, which indicate the precision with which these effects have been estimated. For example, the true effect for perfect pitch is estimated to be between -0.13 and 3.42 MET score units, on average, at the 95% level of confidence.
Each of these variables in the final model is of marginal statistical significance using the conventional threshold of statistical significance (5%). The largest change in this analysis from the simple differences found in the univariate analysis is for perfect pitch; in the univariate analysis, the difference of the average MET scores was 2.12. (See Figure 19).

In the regression model, the corresponding effect was 1.65. The main reason for this is that there is a very strong association between having perfect pitch, and doing an exam at grade 6 or higher: among subjects with non-missing data, 24/145 individuals who did an exam at grade 6 or higher had perfect pitch (16.6%) whereas 3/189 who did not do an exam at grade 6 or higher had perfect pitch (1.6%). As a result, when both of these variables are included in the regression model, the effect of perfect pitch is smaller, after adjustment for exam at grade 6 or higher.

The regression model had an $R^2$ value of 3.80%, which indicates that there is a large amount of variation in the MET scores that is not explained by the model.

**Conclusion**

The analysis of results presented in this chapter did not identify any significant association between most of the training variables. Of the pre-existing variables, as regression modelling showed, even perfect pitch was not a strongly significant predictor of melodic pattern audiation. The MET was considered a suitable test for the first part of this study because it required no previous training, and in particular, no knowledge of notation or musical theory. This was aimed at allowing for the possibility that some musicians were less familiar with notation skills than others. In contrast to this, the test for tonal understanding (MTT) requires a functional knowledge of notation and theory. Usually these skills require a significant amount of musical training. Therefore, the results on the music transcription task to be presented in the next chapter will provide an important source of triangulation of the data in this study.
CHAPTER 7: RESULTS/ANALYSIS: TONAL UNDERSTANDING

A core aim of this study was to establish the degree to which trained musicians understand tonal music. Tonal understanding (TU) was defined as a specific form of audiation in which a musician could recognize heard or imagined tonal music allowing them to reproduce it on an instrument or write it down in notation. It involved a three-stage sequential cognitive process of inferring a tonal centre, perceiving melodic contour and identifying scale degrees of melody notes (Karpinski, 2000). A pre-existing transcription task was selected for the purpose of measuring tonal understanding in musicians.

This chapter reports on the analysis of results on the test for tonal understanding, the Music Transcription Task (MTT). The results to be reported will be analyzed in relation to the same training and pre-existing variables as described in the previous chapter for the MET. The final part of the analysis deals with the development of a predictive model of tonal understanding. The chapter begins with a description of the procedure for the Music Transcription Task.

Music Transcription Task (MTT)

The music transcription task (MTT) was taken from the 2001 NSW Year 12 music examination (Studies, 2015). The musical excerpt to be transcribed was an excerpt from a performance of “Six Ceylan Songs” composed by Michael Nyman (1990).

MTT Procedure

The same format of the original 2001 test procedure was followed. An audio file was used that contained the original verbal instructions for the test, and the original recording of the excerpt repeated six times, with the exact sequence of timed pauses inserted between repeats. The original blank test sheet (de-identified) was also used (see appendix 5). This sheet contained written instructions for the test which were almost identical to the spoken instructions on the audio file.

After the MET was administered, there was a pause of about a minute to allow participants to rest and prepare for the next test. The MTT was introduced by explaining that participants would be required to write down the voice melody of the piece they were about to hear. There would be six playings. Participants were asked if there were any questions. If there were none, the test began. The beginning of the audio included the original spoken instructions of the HSC test. These were as follows: “The melody dictation. Bars one to ten will be played six times for you to notate bars three to nine of the voice part. The rhythm is indicated above the stave. Here is the first playing”.

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MTT Scoring

For comparison purposes with the original 2001 examination, scoring of the MTT followed the marking criteria used in the scoring of the 2001 examination. These criteria are shown in Table 13.

Table 13: MTT Marking Rubric

<table>
<thead>
<tr>
<th>Marks</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Correctly completes the pitch</td>
</tr>
<tr>
<td>4</td>
<td>Completes the pitch almost correctly—minor errors but intervallic relationships are correct</td>
</tr>
<tr>
<td>3</td>
<td>Contour correct and majority of intervals and pitch correct, or Initial error may cause a shift in pitch throughout although contour and intervallic relationships correct</td>
</tr>
<tr>
<td>2</td>
<td>Contour correct but intervals inaccurate. Some notes may be correct pitch</td>
</tr>
<tr>
<td>1</td>
<td>Contour generally correct for at least two bars</td>
</tr>
</tbody>
</table>

(Studies, 2015)

Using this as a guide, responses on the MTT were scored and entered into the Excel worksheet next to the participant identification number. It is important to note that in the original 2001 marking guidelines as shown above, one mark was awarded if the contour of the transcription was generally correct for at least two bars. This was considered to imply that if contour was not correct for at least two bars, then no mark should be awarded. For this reason zero marks were awarded if contour was not correct for at least two bars.

Below are examples of responses on the MTT for each of the marking categories. The actual handwritten responses are included here because they provide an important indication of the large variation in notational skills among participants. Background information on each participant is also included. It is important to emphasize that most of the following responses are from musicians who have already completed a tertiary degree in instrumental music, studied music at secondary school, and have achieved recitation performance at the very highest examination level. (Level 9 = Associate; Level 10 = Licentiate).
MTT Scoring Example Responses

MTT 5 Marks

Figure 24 shows a response that was awarded five marks. All pitches are correct. Note the neat and well proportioned notation. This participant reported:

- level 9 examination
- perfect pitch
- mixture of music
- learns from notation
- lessons based on Suzuki and Yamaha
MTT 4 Marks

![MTT Example 4 marks](image)

Figure 25: MTT Example 4 marks

Figure 25 shows a response that was awarded 4 marks: almost correct. The annotations above the stave are interesting because they clearly indicate this participant has assigned the correct scale degree to each note. Missing accidentals on the Bb and the Eb, however, require deducting one mark. Despite this it seems clear that this participant has tonal understanding. Notation is neat and well proportioned. This participant reported:

- BMus completed
- level 10 examination
- classical
- learns from notation
MTT 3 Marks:

Figure 26 shows a response that was awarded 3 marks. Contour and majority of intervals and pitches are correct. However, in the final bars, failure to identify the Bb tonal centre is an important error. This response shows that perfect pitch does not guarantee tonal understanding. This participant reported:

- BMus completed
- Year 12 music
- level 8 examination
- classical
- perfect pitch
- notation
- lessons Yamaha based
MTT 2 Marks

Figure 27 shows a response that was awarded 2 marks. Contour is correct throughout. Some pitches are correct. But almost all of the intervals are markedly inaccurate and there is no indication of a tonal centre. As with many other responses, this participant failed to audiate that the first interval was a simple minor third and like many other responses, in the final bars, the failure to identify the simple scale step do-re-do is remarkable: especially, that the third last and last notes are the same. This participant reported:

- BMus completed
- Year 12 music
- classical
- notation
MTT 1 Mark

Figure 28 shows a response that was awarded 1 mark. Contour is generally correct for at least two bars. But most pitches are incorrect including importantly the opening interval to the tonic Bb. In the second section, a semi-tone is used instead of the ascending scale in thirds and the contour here is not correct. This participant reported:

- Level 10 examination
- Year 12 music
- notation
MTT 1 Mark

Figure 29 shows a response that was awarded 1 mark. This response is largely incomplete and with almost all pitches incorrect showing no indication of tonal understanding. Technically however, the contour of the second section is correct for at least two bars which obliged awarding one mark. Notation is rudimentary. This participant reported:

- BMus completed
- Year 12 music
- Level 9 examination
- classical
- notation
- lessons Suzuki based
MTT 0 Marks

Figure 30: MTT Example 0 marks

Figure 30 shows a response that was awarded 0 marks. There is an absence of contour perception, even for two consecutive bars and no indication of tonal understanding. Especially notable in the incorrect ascending contour of the final bar, which as in many other examples failed to audiate a simple do-re-do movement. Notation is rudimentary. This participant reported:

- BMus completed
- Year 12 music
- Level 9 examination
- classical
- notation
CHAPTER 7: RESULTS/ANALYSIS: TONAL UNDERSTANDING

MTT Results

Using the HSC 2001 marking guidelines, the results on the music transcription task for the total sample were as follows (Table 14).

Table 14: MTT Distribution of Scores

<table>
<thead>
<tr>
<th>Score</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>73</td>
<td>21.4</td>
</tr>
<tr>
<td>1</td>
<td>131</td>
<td>38.5</td>
</tr>
<tr>
<td>2</td>
<td>42</td>
<td>12.3</td>
</tr>
<tr>
<td>3</td>
<td>22</td>
<td>6.4</td>
</tr>
<tr>
<td>4</td>
<td>29</td>
<td>8.5</td>
</tr>
<tr>
<td>5</td>
<td>43</td>
<td>12.6</td>
</tr>
<tr>
<td>Total</td>
<td>340</td>
<td>100</td>
</tr>
</tbody>
</table>

The results shown in Table 14 show that about three quarters (72%) of the tertiary musicians scored in the lower range of 0, 1 and 2 marks. Only a small proportion (13%) of the tertiary trained musicians successfully completed the task designed for secondary school students. To assist in answering the research question, it was necessary to establish the difficulty level of the task. In order to do this, it was valuable to examine how the original secondary music students performed on the task.

MTT Tertiary Versus Secondary Results

In order to assist in establishing a reference point for the results on the MTT, the original 2001 NSW Year 12 music examination results were obtained from the BOS. These are shown alongside the present tertiary results in Table 15.

Table 15: MTT Results Tertiary Versus Secondary

<table>
<thead>
<tr>
<th>Score</th>
<th>Secondary</th>
<th>Tertiary</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>147</td>
<td>27</td>
</tr>
<tr>
<td>2</td>
<td>228</td>
<td>42</td>
</tr>
<tr>
<td>3</td>
<td>59</td>
<td>11</td>
</tr>
<tr>
<td>4</td>
<td>51</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>53</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>539</td>
<td>100</td>
</tr>
<tr>
<td>Mean</td>
<td>2.3</td>
<td>1.8</td>
</tr>
</tbody>
</table>
Figure 31 compares the secondary results with the tertiary results of this present study. The results of the secondary and tertiary groups are broadly similar particularly at the higher levels of three, four and five marks. The almost complete absence of zeros in the NSW HSC data is surprising, since many of the tertiary students scored zero. It may be that in the NSW HSC testing there was a convention to award a mark for some sort of attempt; in the present study, scores were assigned strictly according to the rubric. As will be discussed in the following section, this discrepancy at the low end of the scale is not important as an indicator of tonal understanding.

Tonal Understanding Results

Although the MTT rubric awards marks from zero to five for the various results, the differences between the competencies are not equal; the scale is not linear. Within the six categories however, there is an important subdivision. Marks 3, 4 and 5 indicate tonal understanding: that is, perception of a tonal centre, contour and scale degrees. In contrast, marks of 0, 1 and 2 relate to perception of melodic contour, regardless of any indication of specific pitches or tonal centre. Because perception of melodic contour is of peripheral relevance to this study, results were divided into two categories: those which indicate tonal understanding (marks 3, 4 and 5), and those which indicate no such understanding (0, 1, and 2).
The differences between marks 3, 4 and 5, are relatively minor. As the above examples illustrate, the difference between 4 and 5 may be a minor error such as a failure to include an accidental. (See Figure 25, for example). A mark of 3 shows that the majority of intervals and pitches are correct, and that the participant has demonstrated tonal understanding. Therefore, reducing the MTT data into these two categories presents a minimal loss of information relevant to this study. As Figure 31 shows, this subdivision was also evident in the original Year 12 results. A large drop in results between the marks of 2 and 3 suggests a natural division of competencies.

**Tonal Understanding: Tertiary Versus Secondary**

For this present tertiary study, the MTT results were reduced to two groups (marks 3,4,5) or no understanding (marks 0,1,2). In all of what follows of the analysis of the MTT, the group defined by scoring 3, 4 or 5 on the MTT is labelled the “tonal understanding (TU)” group. This showed that only 28% (n = 94) of tertiary musicians showed tonal understanding. The same data reduction process was carried out for the secondary NSW HSC results which showed that 30% (163) of the secondary students had tonal understanding (See Figure 32). These percentages are not statistically significantly different (P = 0.45, Fisher’s exact test).

![Figure 32: TU %, Secondary Versus Tertiary, Estimates and 95% CI](Figure32.jpg)
Summary
The preceding analysis of results on the MTT indicated the following findings:

- One quarter (28%) of tertiary musicians showed TU of the relatively simple melody heard six times.
- Three quarters (72%) of tertiary musicians showed no TU of the melody.
- 39% of tertiary musicians were limited to representing only melodic contour for two consecutive bars or more.
- 21% of tertiary musicians were unable to represent melodic contour for at least two consecutive bars.
- Many tertiary musicians showed limited understanding of the elemental intervals of the Western major scale.
- Many tertiary musicians were unable to infer any tonal centre in a heard melody.
- There was no evidence that tertiary trained musicians performed any better on this task than Year 12 secondary students.

In order to examine what background factors may be associated with TU, the next phase of the analysis focuses on information gathered from the questionnaire in relation to factors that may be associated with the previous analysis of results on the MTT.

TU and Notation Skill
The preceding analysis showed that most of the tertiary musicians did not show TU of the MTT melody. A transcription task such as the MTT relies heavily on a functional knowledge of notation skills. It seems possible to attribute the results on the MTT not to limited TU but rather to the consequence of limited skills in transferring heard music onto notation. To investigate the possibility that results on the MTT could be attributed to difficulties with notation, the results of the notation test (MTT) were analyzed in relation to the results on the non-notation test (MET). The research question being addressed was the degree of association between TU and melodic pattern audiation. Figure 33 shows the MTT and MET scores for the total sample.
In Figure 33 each of the 340 dots represent a participant’s total score on the MET out of 52. These individual MET results are then grouped according to the score each participant had on the MTT (0-5); the points are jittered slightly on the horizontal scale to avoid over-printing.

![Figure 33: MET Versus MTT](image)

The sloping line across the graph represents the linear association between the two measures. The upward slope of the line shows that MET and MTT are significantly correlated. The correlation between the MET and the MTT is $r = 0.37$ ($P < 0.001$). As the mean scores on the MET rise so do scores on the MTT.

To further investigate what factors are associated with differences in TU in trained musicians, the following section analyzes the results on the MTT in relation to the training and pre-existing variables obtained from the questionnaire.

**TU and Musical Training**

The range of results on the MTT shows that some musicians have better developed TU than others. There is a strong inference in the literature that there are significant differences in audiation ability among groups of musicians, and that these differences are based on differences in the type of music they play, and the way they learn and perform. A key question of this study was the extent to which musical training may be associated with TU.
Results of the MTT were analyzed in relation to the variables obtained from the questionnaire. The approach taken to the analysis of TU here was directly analogous to the analysis of the MET in the preceding chapter; the only difference being that TU is a binary outcome, rather than numerical. First, the univariate associations between TU and the variables were considered in the same groupings as used in chapter 6, namely, training and pre-existing factors. Of these variables, all but one are categorical. The one that is not categorical is “Years since started musical training”. Since this is numerical, the univariate association between this explanatory variable and TU was assessed using logistic regression. The explanatory variables for training were considered in the following categories:

**Type of training:** music played; way of learning; instrument; teaching method

**Extent of training:** years since starting; examinations; secondary and tertiary training

**Type Of Training**

There is a strong inference in the literature that there may be significant differences in audiation ability among groups of musicians, and that these differences may be associated with differences in the way musicians learn and perform. Tables 16 through to 24 show all of the associations between the results on the MTT and type of training. Each of these variables will be dealt with separately.

For the P-values shown in Tables 16 to 24, the hypothesis test was either a chi-square test, if the variable had three or more levels, or Fisher’s exact test, when the variable had two levels.

**TU and Type of Music Played**

In the questionnaire, participants reported that the main type of music they played was either classical, popular or a mixture of both. Table 16 shows the percentage of each of these groups who demonstrated TU.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Level</th>
<th>n</th>
<th>TU%</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of music</td>
<td>Classical</td>
<td>61</td>
<td>144</td>
<td>42 (34.2%, 50.9%)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>Popular</td>
<td>7</td>
<td>119</td>
<td>6 (2.4%, 11.7%)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>Mixture</td>
<td>26</td>
<td>77</td>
<td>34 (23.4%, 45.4%)</td>
<td></td>
</tr>
</tbody>
</table>

Almost half the classical musicians (42%) and a third of the mixture group (34%) demonstrated TU. Only seven out of 119 popular musicians (6%), demonstrated TU.
**Way Of Learning**

Participants reported that their main way of learning music was either by notation (45%), by ear (12%), or a mixture of both (43%). Table 17 shows the percentage of each group who demonstrated TU.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Level</th>
<th>TU</th>
<th>n</th>
<th>TU%</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notation</td>
<td></td>
<td>54</td>
<td>153</td>
<td>35</td>
<td>(27.7%, 43.4%)</td>
<td></td>
</tr>
<tr>
<td>Way of learning</td>
<td>Ear</td>
<td>2</td>
<td>42</td>
<td>5</td>
<td>(0.6%, 16.2%)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>Combination</td>
<td>38</td>
<td>145</td>
<td>26</td>
<td>(19.2%, 34.2%)</td>
<td></td>
</tr>
</tbody>
</table>

The ear learners performed remarkably poorly on the MTT compared to their reading counterparts. Only two out of 42 ear learners (5%) demonstrated TU. This compares with one third of notation readers (35%) and a quarter of the combination group (26%).

**Type Of Instrument**

Table 18 shows the percentage of each of instrumental group who demonstrated TU.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>TU</th>
<th>n</th>
<th>TU%</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keyboard</td>
<td>33</td>
<td>72</td>
<td>46</td>
<td>(34.0%, 58.0%)</td>
<td></td>
</tr>
<tr>
<td>Strings</td>
<td>15</td>
<td>41</td>
<td>37</td>
<td>(22.1%, 53.1%)</td>
<td></td>
</tr>
<tr>
<td>Woodwind</td>
<td>17</td>
<td>48</td>
<td>35</td>
<td>(22.2%, 50.5%)</td>
<td></td>
</tr>
<tr>
<td>Brass</td>
<td>10</td>
<td>29</td>
<td>35</td>
<td>(17.9%, 54.3%)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Voice</td>
<td>12</td>
<td>54</td>
<td>22</td>
<td>(12.0%, 35.6%)</td>
<td></td>
</tr>
<tr>
<td>Guitar</td>
<td>5</td>
<td>61</td>
<td>8</td>
<td>(2.7%, 18.1%)</td>
<td></td>
</tr>
<tr>
<td>Percussion</td>
<td>2</td>
<td>35</td>
<td>6</td>
<td>(0.7%, 19.2%)</td>
<td></td>
</tr>
</tbody>
</table>

There were large variations in TU among different instrument categories. This is in contrast to the results on the MET which indicated almost no difference in melodic pattern audiation no matter what instrument a person played.

Almost half the Keyboardists showed TU (46%). Strings, Woodwind and Brass players all had about one third with TU. Guitarists and Percussionists showed markedly lower levels of TU, 8% and 6% respectively.
Teaching Method
97% of participants (331) had received lessons on their principal instrument. Of those participants who had lessons, 47 (14%) nominated a specific “method” of instrumental music teaching (shown at Table 10). The 47 were made up predominantly of three methods: Suzuki (24), Yamaha (10) and Kodaly (7). All of these teaching methods are known to emphasize aural learning practices.

Due to the limitations of this study, these categories were not well defined. It was not possible to accurately establish to what extent the participants learned in a particular method, nor for what period of time and so on, something that would present challenges even with unlimited resources. Despite these limitations a significant effect was evident in the results.

Table 19 divides the total sample into two groups: those who learned by a particular method and those who did not. It then compares the proportion from each group who demonstrated TU.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Level</th>
<th>TU</th>
<th>n</th>
<th>TU%</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching method</td>
<td>Method</td>
<td>21</td>
<td>47</td>
<td>45</td>
<td>(30.2%, 59.9%)</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>No method</td>
<td>73</td>
<td>293</td>
<td>25</td>
<td>(20.1%, 30.3%)</td>
<td></td>
</tr>
</tbody>
</table>

Table 19 shows that a significantly higher proportion of the method learners had TU. Almost half of the method learners (45%) had TU compared with only a quarter of the no-method learners (25%).

Extent Of Training

Years Since Start Of Training
The first variable considered for extent of training was the number of years since a participant had begun learning an instrument. As mentioned previously it was outside the scope of this study to gather an exhaustive account of participants’ time spent learning an instrument. But the information about the time since starting musical training was intended to provide some guide to amount of training on an instrument.

Since this variable is numerical, the univariate association between this explanatory variable and TU was assessed using logistic regression. The odds of TU were estimated to increase by a factor of 1.84 (95% confidence interval: (1.23 to 2.73), P = 0.002) for each additional 10 years since the start of musical training.
This result contrasts markedly with the results on the MET for this variable. There was no advantage for years of training for melodic pattern audiation. (The correlation between the MET and Years since start of training was \( r = 0.03 \) (\( P = 0.563 \)). The associations between TU and the extent of training variables are shown in Table 20.

Table 20: Associations Between TU and Training Extent Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Level</th>
<th>TU</th>
<th>( n )</th>
<th>TU%</th>
<th>95% CI</th>
<th>( P )-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Grade 6+</td>
<td>Yes</td>
<td>63</td>
<td>147</td>
<td>43</td>
<td>(34.7%, 51.3%)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>31</td>
<td>193</td>
<td>16</td>
<td>(11.2%, 22.0%)</td>
<td></td>
</tr>
<tr>
<td>Year 12 music</td>
<td>Yes</td>
<td>76</td>
<td>271</td>
<td>28</td>
<td>(22.8%, 33.7%)</td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>16</td>
<td>63</td>
<td>25</td>
<td>(15.3%, 37.9%)</td>
<td></td>
</tr>
<tr>
<td>BMus</td>
<td>Yes</td>
<td>92</td>
<td>313</td>
<td>29</td>
<td>(24.4%, 34.8%)</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>2</td>
<td>27</td>
<td>7</td>
<td>(0.9%, 24.3%)</td>
<td></td>
</tr>
</tbody>
</table>

**Level Of Instrumental Examinations**

Time spent preparing for instrumental examinations may be an important training factor associated with TU. Nearly half of the total sample (43.2%) had achieved an instrumental examination level of grade six or higher. This represents at least six or more years of lessons, practice and performance. Table 21 divides the total sample into two groups: those with an examination level of grade six or more, and those without. It then compares the proportion from each group who demonstrated TU.

Table 21: TU and Exam of Grade 6 or higher

<table>
<thead>
<tr>
<th>Variable</th>
<th>Level</th>
<th>TU</th>
<th>( n )</th>
<th>TU%</th>
<th>95% CI</th>
<th>( P )-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Grade 6+</td>
<td>Yes</td>
<td>63</td>
<td>147</td>
<td>43</td>
<td>(34.7%, 51.3%)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>31</td>
<td>193</td>
<td>16</td>
<td>(11.2%, 22.0%)</td>
<td></td>
</tr>
</tbody>
</table>

Almost half of those with a high examination (43%) demonstrated TU. This compares to only 16% for the non-examination group. Analyzed individually, this is a significant effect. As will be shown in the next section however, subsequent modelling showed that the variable of high grade examination is not a significant predictor of TU.
CHAPTER 7: RESULTS/ANALYSIS: TONAL UNDERSTANDING

Secondary And Tertiary Training

80% of participants had studied music as a Year 12 subject, and most probably for several years before that. Almost all participants (92%) had completed or were completing a BMus. Table 22 shows the proportions of these participants with TU.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Level</th>
<th>TU</th>
<th>n</th>
<th>TU%</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 12 music</td>
<td>Yes</td>
<td>76</td>
<td>271</td>
<td>28</td>
<td>(22.8%, 33.7%)</td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>16</td>
<td>63</td>
<td>25</td>
<td>(15.3%, 37.9%)</td>
<td></td>
</tr>
<tr>
<td>BMus</td>
<td>Yes</td>
<td>92</td>
<td>313</td>
<td>29</td>
<td>(24.4%, 34.8%)</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>2</td>
<td>27</td>
<td>7</td>
<td>(0.9%, 24.3%)</td>
<td></td>
</tr>
</tbody>
</table>

There was no significant difference in TU whether a person had studied music at secondary school (28%) or not (25%). Training at BMus level, however, did show a significant advantage over courses other than a BMus. 29% of the BMus students demonstrated TU, in comparison to only 7% of the non-BMus tertiary students. Taken individually this is a significant difference. Again, however, as will be shown later, further modelling found that when taken in combination with other variables, tertiary study at BMus level was not a significant predictor of TU.

TU And Pre-existing Factors

To investigate what pre-existing factors might be associated with TU in trained musicians, the same pre-existing variables as in the MET analysis were considered, namely: gender; language; perfect pitch; attributed value. The univariate associations between TU and pre-existing traits are represented in Table 23.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Level</th>
<th>TU</th>
<th>n</th>
<th>TU%</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Female</td>
<td>45</td>
<td>156</td>
<td>29</td>
<td>(21.9%, 36.6%)</td>
<td>0.902</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>48</td>
<td>173</td>
<td>28</td>
<td>(21.2%, 35.1%)</td>
<td></td>
</tr>
<tr>
<td>Language</td>
<td>Asian</td>
<td>17</td>
<td>25</td>
<td>68</td>
<td>(46.5%, 85.1%)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>European</td>
<td>77</td>
<td>315</td>
<td>24</td>
<td>(19.8%, 29.6%)</td>
<td></td>
</tr>
<tr>
<td>Perfect pitch</td>
<td>Yes</td>
<td>23</td>
<td>27</td>
<td>85</td>
<td>(66.3%, 95.8%)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>68</td>
<td>307</td>
<td>22</td>
<td>(17.6%, 27.2%)</td>
<td></td>
</tr>
<tr>
<td>Rating of aural skill</td>
<td>A little</td>
<td>1</td>
<td>9</td>
<td>11</td>
<td>(0.3%, 48.2%)</td>
<td>0.411</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>11</td>
<td>45</td>
<td>24</td>
<td>(12.9%, 39.5%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>82</td>
<td>280</td>
<td>29</td>
<td>(24.0%, 35.0%)</td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER 7: RESULTS/ANALYSIS: TONAL UNDERSTANDING

**Gender**

In this univariate analysis, there was no significant effect of gender on MTT scores with approximately one quarter of both groups showing TU.

**Language**

A person’s native language was significantly associated with TU. Only 24% of European speakers showed TU compared with 68% of Asian speakers. This large difference is interesting given that Asian language speakers accounted for only a small proportion of the total sample: 7%.

**Perfect Pitch**

The advantages of perfect pitch were evident in the results for TU. 27 participants reported having perfect pitch. Almost all of these (85%) showed TU. Of the participants without perfect pitch, only one in five (22%) had TU.

Figure 34 shows the advantages of perfect pitch over ordinary participants in each type of music played. Note that a mark of 3 or higher indicated TU. The means of TU in the classical and mixture groups were easily above the mark of 3. For ordinary musicians, the means for classical and mixture groups did not reach the threshold to indicate TU. The mean of the popular music group, with or without perfect pitch did not reach TU.

Figure 34: MTT By Type of Music and Perfect Pitch
A similar advantage was found for perfect pitch in way of learning. Figure 35 shows the advantages of perfect pitch over ordinary musicians in each way of learning.

![Figure 35: MTT By Way of Learning and Perfect Pitch](image)

**Participant Rating of Aural Skills**

Participants were asked in the questionnaire “how important do you rate aural skills as part of becoming an excellent musician?”. The possible responses were: highly; moderately; a little; not very; not at all.

Most participants (84%) considered aural skills to be highly important to developing music performance expertise. Almost all the remainder (13%) considered them the next highest value “moderately”. Only 3% considered aural skills to be “a little” important. No-one considered aural skills to be “not very” or “not at all” important. In total 97% of participants reported that they valued aural skill as an important aspect of their musical training. Table 24 shows the distribution of responses to that question for those with TU.

**Table 24: Association Between TU and Rating of Aural Skill**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Level</th>
<th>TU</th>
<th>n</th>
<th>TU%</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rating of aural skill</td>
<td>A little</td>
<td>1</td>
<td>9</td>
<td><strong>11.1</strong></td>
<td>(0.3%, 48.2%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>11</td>
<td>45</td>
<td><strong>24.4</strong></td>
<td>(12.9%, 39.5%)</td>
<td>0.411</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>82</td>
<td>280</td>
<td><strong>29.3</strong></td>
<td>(24.0%, 35.0%)</td>
<td></td>
</tr>
</tbody>
</table>
The high value placed on aural skills is in stark contrast to the results. Approximately three-quarters (73%) of tertiary music students showed no TU. Of the nine people who said “a little”, only one showed TU. Only 24% of the “moderate” group showed TU. And of those who rated audiation highly, a little over one in four (29%) showed any TU. These results may suggest that a person’s opinion of the value of audiation may not be strongly associated with audiation.

TU Predictive Model

The next process was analogous to the model-fitting carried out for the MET in the previous chapter. After the univariate analyses (one explanatory variable per analysis) shown above, a process of obtaining a predictive model using several variables simultaneously was followed. This analysis was to evaluate the relative importance of each of the variables, and to identify those that were most strongly associated with TU in trained musicians.

All variables were included in a logistic regression model, and a backward stepwise procedure was used to successively remove variables until all remaining variables were statistically significant predictors at the 10% level.

The same explanatory variables as shown above were considered, namely: Years of training; Gender; Language; Perfect Pitch; Instrument; Type of music played; Main way of learning; Method or not; Exam at Grade 6 or not; BMus; Year 12 music; Rating of aural skills.

Among the 340 subjects, there were missing values on some of these variables, as follows: Years since started musical training: 4; Gender: 11; Perfect Pitch: 6; Year 12 music: 6; Rating of aural skills: 6. In combination, there were 31 subjects (9.1%) with missing data on at least one of these variables. For the purposes of fitting the logistic regression model, listwise deletion was used, so that the model selection was carried out on the remaining 309 subjects, which are the same 309 subjects used for modelling the MET. All variables were considered, and a backward stepwise procedure was used to successively remove variables until all remaining variables were statistically significant predictors at the 10% level. When this process was followed, the variables that remained in the model were gender, language, perfect pitch, type of music and way of learning.

The results of this analysis are expressed in two ways here. The first, Table 25, shows the odds ratios and 95% confidence intervals for the fitted model.
The odds ratios in this table express the strength of the association between the variable and the probability of TU, adjusted for the other variables in the model. For example, the odds of TU for those whose language group was “Asian” were estimated to be 4.9 times higher than for those with an “Other” language group, after adjusting for gender, perfect pitch, type of music played and main way of learning.

Table 25: Results of Logistic Regression Modelling, TU and Explanatory Variables Odds ratios and 95% Confidence Intervals

<table>
<thead>
<tr>
<th>Variable</th>
<th>Level</th>
<th>Baseline</th>
<th>Odds ratio</th>
<th>95% CI</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male</td>
<td>Female</td>
<td>2.1</td>
<td>(1.1 to 3.8)</td>
<td>0.020</td>
</tr>
<tr>
<td>Language group</td>
<td>Asian</td>
<td>Other</td>
<td>4.9</td>
<td>(1.7 to 14.2)</td>
<td>0.002</td>
</tr>
<tr>
<td>Perfect pitch</td>
<td>Yes</td>
<td>No</td>
<td>12.9</td>
<td>(4.0 to 41.8)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Type of music played</td>
<td>Classical</td>
<td>Mixture</td>
<td>1.8</td>
<td>(0.9 to 3.7)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>Classical</td>
<td>Popular</td>
<td>9.4</td>
<td>(3.3 to 26.3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mixture</td>
<td>Popular</td>
<td>5.3</td>
<td>(2.0 to 14.2)</td>
<td></td>
</tr>
<tr>
<td>Main way of learning</td>
<td>Combination</td>
<td>Notation</td>
<td>1.6</td>
<td>(0.8 to 3.1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Combination</td>
<td>Ear</td>
<td>15.8</td>
<td>(1.0 to 254)</td>
<td>0.023</td>
</tr>
<tr>
<td></td>
<td>Notation</td>
<td>Ear</td>
<td>10.0</td>
<td>(0.6 to 161)</td>
<td></td>
</tr>
</tbody>
</table>

* P-value shown is for the global null hypothesis (all levels equal) in the case of the explanatory variables with three levels.

Perfect pitch is the variable with the strongest effect: it has a large odds ratio (12.9) and is very statistically significant. This has been observed previously based on an unadjusted association; this model shows that the effect is not removed by adjusting for the other variables in the model.

Classical musicians had better TU than those who played a mixture, and both had much better TU than the popular musicians. Those who learned from a mixture of ear and notation had better TU than those mainly learning from notation. Both of these groups had much better TU than the ear learners.

Predicted Percentages of TU

An alternative way of representing the predictive model is expressed in Table 27. The fitted logistic regression models the probability of having TU; it is therefore possible to determine the estimated probability of TU, for each combination of the explanatory variables, based on the model. These are shown in Table 27, expressed as percentages. For example, (underlined in Table 27) for female subjects with an Asian language group who do not have perfect pitch, play mainly classical and learned by notation, the predicted percentage of TU based on the model is 62%. In the actual dataset, there were seven such subjects, four of whom had TU, an actual percentage of 57% (= 4/7). Note that although Table 27 only shows percentages for those categories that were present in the study, the fitted model provides the estimated probability of TU for any of the categories of the table.
CHAPTER 7: RESULTS/ANALYSIS: TONAL UNDERSTANDING

TU and Gender

Note that in the logistic regression model, an association between gender and TU was found (See Table 25). On the other hand, the univariate association between gender and TU was not at all marked or statistically significant (see Table 23). The explanation for this is as follows. The type of music played was very strongly associated with TU, as shown in the logistic modelling. “Classical” respondents had substantially better TU than “popular”. Also, the percentage of classical respondents who were female was 60%, and markedly higher than the percentage of classical respondents who were male (28%). When considering the levels of type of music played separately, the percentages of TU among males was consistently higher than for females, as shown in Table 26.

Table 26: TU By Gender and Type of Music Played

<table>
<thead>
<tr>
<th>Gender</th>
<th>Classical</th>
<th>Popular</th>
<th>Mixture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>36/94 (38.3%)</td>
<td>1/29 (3.5%)</td>
<td>8/33 (24.2%)</td>
</tr>
<tr>
<td>Male</td>
<td>25/48 (52.1%)</td>
<td>6/84 (7.1%)</td>
<td>17/41 (41.5%)</td>
</tr>
</tbody>
</table>

Hence, after adjustment for “type of music played”, there is a marked gender effect shown: males had higher percentages of TU than females.
## Table 27: Predicted Percentage of TU Based on the Logistic Regression Model Fitted

<table>
<thead>
<tr>
<th>Notation</th>
<th>Perfect Pitch</th>
<th>Classical</th>
<th>Mixture</th>
<th>Popular</th>
<th>No</th>
<th>Classical</th>
<th>Mixture</th>
<th>Popular</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Male</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>77%</td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>Other</td>
<td>90%</td>
<td>83%</td>
<td>*</td>
<td>40%</td>
<td>27%</td>
<td>7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Female</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td>95%</td>
<td>92%</td>
<td>*</td>
<td>*</td>
<td>62%</td>
<td>48%</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>81%</td>
<td>*</td>
<td>*</td>
<td>25%</td>
<td>16%</td>
<td>3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Combination</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>84%</td>
<td>74%</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td>93%</td>
<td>88%</td>
<td>*</td>
<td>*</td>
<td>51%</td>
<td>37%</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>97%</td>
<td>*</td>
<td>*</td>
<td>72%</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ear</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Asian</td>
<td>67%</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>Other</td>
<td>*</td>
<td></td>
<td>*</td>
<td>3%</td>
<td>2%</td>
<td>0%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* signifies there were no participants in this category.
Simpson’s Paradox

Table 26 is remarkable as an example of Simpson’s paradox: where trends observed in different groups of data disappear when the groups are combined. In Table 26, the percentages of TU shown in brackets are up to twice as high for the males compared with females. This gives the appearance that males have a large advantage over females in TU. However this large advantage disappears when the “type of music” groups are combined and totalled as in Table 28.

Table 28: TU Percentages and Gender

<table>
<thead>
<tr>
<th>Variable</th>
<th>Level</th>
<th>TU</th>
<th>n</th>
<th>TU%</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Female</td>
<td>45</td>
<td>156</td>
<td>29</td>
<td>(21.9%, 36.6%)</td>
<td>0.902</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>48</td>
<td>173</td>
<td>28</td>
<td>(21.2%, 35.1%)</td>
<td></td>
</tr>
</tbody>
</table>

As well as being a good example of Simpson’s paradox, Table 26 is a good example of quite strong confounding which can occur with univariate analysis, which multiple logistic regression modelling is able to adjust for.

Conclusion: TU

The results of the MTT presented in this chapter provide an important complement to the results of the non-notation MET. The following chapter discusses the results as they relate to the research questions, as well as discussing the significance and implications of the findings within the broader picture of music education.
CHAPTER 8: DISCUSSION AND CONCLUSIONS

The broad question underlying this thesis was an enquiry into optimal ways of acquiring instrumental music expertise. Audiation, and in particular TU were identified as a fundamental aspect of instrumental music performance expertise, the equivalent in language to thinking. The specific focus of the study concerned a lack of evidence for numerous claims that audiation was not well developed in many formally trained musicians. This aim of this study was to provide empirical evidence about these claims, as well as to investigate background factors associated with audiation and TU.

The analysis of results presented in the previous two chapters has provided some empirical evidence relevant to many of the claims discussed earlier in this thesis. The broad picture to emerge from the analysis appears to confirm the claims that many formally trained musicians in Australia lack TU. Formal training does not appear to be significantly associated with audiation development generally. Rather, pre-existing factors appear to be most strongly associated with these abilities.

The following chapter discusses the results first in relation to the research questions of the study. The broader implication of the findings are then discussed in relation to the theory underpinning this study, on the acquisition of music performance expertise. The implications of the findings for current practice are also discussed. The last part of the chapter is the summary and conclusions of the entire thesis. The results of the preceding analysis are discussed according to the following nine research questions.

Melodic Pattern Audiation

Question 1: What structural aspects of melodies are associated with melodic pattern audiation?

The analysis of the 52 MET results showed a clear hierarchy of difficulty in melodic pattern audiation. Certain patterns were harder than others to audiate. Part of the aim of this study was to identify factors that might be associated with audiation skill. An analysis of the structural features of the individual MET melodies showed an association with audiation difficulty.

The most significant factor in melodic pattern audiation was predictability: Tonal patterns, major or minor, were much easier to audiate than atonal ones. This confirmed research by Holahan and Saunders (1997).

The type of alteration was important. The hardest patterns to audiate were atonal, where the difference was caused by a pitch alteration. This confirms a finding by Holahan and Saunders (1997) that items with the same contour but with a pitch alteration were consistently more difficult for participants of all levels.
For the tonal patterns, the issue of sameness or difference was not an important factor in audiation difficulty. It was only for the atonal patterns that sameness or difference became an important factor. For atonal patterns, sameness was much easier to audiate than difference. This was emphasized by the finding that the five hardest MET patterns were atonal, and different.

If the pattern alteration was a change in contour, this made the patterns easiest to audiate. Almost all participants were able to correctly audiate when a pattern changed in contour regardless of whether the pattern was major, minor or atonal.

This finding supports numerous findings in the literature that contour plays an important role in melodic perception, even in infants (Dowling, 1988, 1999; Trehub, 2000). Contour in music is viewed as an abstraction from melody and is encoded independently from pitch or interval information (Dowling, 1978:346). Importantly for this discussion, it is thought that most adult listeners are able to correctly perceive melodic contour intuitively (Karpinski, 2000:82). That is, contour perception occurs regardless of any musical training. For that reason, it is interesting to consider the possibility that a correct answer on MET patterns that contain a contour change may not be evidence of musical training, but rather a result of the common ability to perceive changes in melodic contour.

The role of musical working memory in pattern audiation was suggested by the analysis of individual MET patterns according to number of tones which showed that the more tones, the harder it was for listeners to correctly audiate the pair of melodies.

The demand of attention required by the MET had the potential to confound results on items nearer the end of the test. The analysis suggested that performance on the MET did not appear to deteriorate due to loss of concentration. In support of this finding, it is worth noting that in all the testing sessions witnessed by the researcher, all participants appeared very attentive and focused on the task with minimal distraction, usually followed by an audible sigh of relief at the end of the test.

**Question 2: To what degree is musical training associated with melodic pattern audiation?**

A core theme underpinning this study was the inference in some literature, as well as anecdotal evidence, that there may be differences in audiation related to different types of musicians, and different ways of learning (Brattico & Tervaniemi, 2006; Green, 2002; Wallentin et al., 2010; Woody & Lehmann, 2010). Perhaps the most compelling finding of the MET analysis then, is that there were no statistically significant differences in melodic pattern audiation associated with types of musicians, nor their learning practices. Results on the MET and analyses of training variables showed no indication of any significant advantage in melodic pattern audiation associated with either the type or extent of musical training experienced by these musicians. Results
were markedly similar across the total sample no matter what kind of music a participant played, the way they learned, the type of teaching they received, or the instrument they played.

This result is interesting because it is in some ways counter-intuitive. One might have expected to see much better pattern audiation in the ear learner group, and the popular musicians who are presumed to spend a majority of their learning in listening-copying practices. This finding is also contrary to numerous claims in the literature, and anecdotal evidence, that popular musicians have superior audiation than their classical counterparts. There is no sign here, for example, of the different brain activations and superior processing of melodic patterns by jazz musicians (Brattico & Tervaniemi, 2006; Woody & Lehmann, 2010).

The lack of any significant difference between types of instruments also seems surprising. Percussionists, for example, necessarily spend a large proportion of their training focusing on rhythmic elements compared to single line instruments such as brass and strings who would focus on melodic and other tonal elements including intonation. Yet, according to these results, current approaches to training on these instruments results in a similar level of pattern audiation ability.

A similar lack of significant effect was found for the extent of a musician’s training. Numerous years of instrumental training and many hours of practice within formal settings at secondary and tertiary level, does not appear to have contributed significantly to the ability to audiate melodic patterns.

The sole training variable that remained in the predictive model after accounting for all other variables was “examination of grade 6 or higher”. There was a small advantage (one MET item) to those who had completed an exam of Grade 6 or higher on their main instrument. The small effect size is interesting because it suggests that at least six years, and up to ten years, of training and practice towards instrumental examinations does not appear to yield a large advantage in melodic pattern audiation compared to others without this extent of training. Although the effect size was small, it is interesting that this was the solitary training variable that remained after adjusting for all other variables. Although aural tests are part of the instrumental examination system they usually play a peripheral role to the main task of music reciting and therefore it is surprising that there is even a small association between doing exams and melodic pattern audiation. It may be that this small effect is due to general musical exposure associated with preparing for instrumental exams.

The lack of association between most measures of training and melodic pattern audiation is in one sense contrary to expectations in the literature. If melodic pattern audiation develops as a result of musical training (Gordon, 2007; Woody & Lehmann, 2010; Karpinski, 2000), one might have expected some difference in pattern audiation between those who studied formally at school and at tertiary level, and those who did not.
Another possibility is that these findings may support the numerous observations in the literature reviewed earlier that formal instrumental music training, as it is currently approached, may provide limited development of audiation (Gordon, 2007; Green, 2002; Jeanneret et al., 2003; Leong, 1999; Serafine, 1988).

Question 3: To what degree are pre-existing traits associated with melodic pattern audiation?

Pre-existing characteristics that occur outside of musical training were the most significant factor in melodic pattern audiation as measured by the MET. Two out of the three variables remaining in the predictive model were: perfect pitch and gender.

The first of these, perfect pitch, is in no way surprising. Perfect pitch is known to yield large advantages in pitch recognition, and in this study perfect pitch was by far the most significant variable in results on the MET regardless of musical training. What is particularly interesting is the lack of strong effect for this variable. Even for those with perfect pitch, the advantage in the 52 item MET test was only about two items on average, not a large advantage. At face value it might have been expected that perfect pitch would have yielded a very significant advantage over those without. One possible explanation is that, as discussed previously, the MET involves judgements about sameness and difference, rather than specific details about the scale degrees involved, or the labelling of the intervals and so on. It seems possible that the common trait of contour recognition may provide the non-perfect-pitch listeners with important assistance in correctly answering the items.

The association of gender in melodic pattern audiation was marginally significant after accounting for all the other variables. Males had a small advantage in melodic pattern audiation over females. Again the effect was not strong: an advantage of about one MET item out of 52. This finding of advantage to males is in contrast to Wallentin et al. (2010) who included gender as a covariate in their analysis of their full model and found no strong effect for gender (F(1,37) = 2.21, P = 0.14). The advantage in audiation to male musicians was also observed in the transcription task.

Question 4: To what degree can melodic pattern audiation be predicted from a musician’s training and pre-existing traits?

Perhaps the most striking finding from analysis of melodic pattern audiation, as measured by the MET, is the absence of strong association with any of the potential explanatory variables. Even on univariate associations, when no other variables are accounted for, the strongest predictor, perfect pitch, was associated with only a 2.1 units difference between those with and without perfect pitch. This is not a large difference, considering the effective range of the MET (25 to 52).
When multivariate modelling was carried out, with a systematic approach to obtaining a predictive model that allows for several variables simultaneously, the three variables in the model accounted for only a small amount of the total variation in the MET ($R^2 = 3.80\%$), indicating that there is a large amount of unexplained variation.

One way to account for this may be that the potential explanatory variables did not fully or adequately encompass the underlying predictive mechanisms in melodic pattern audiation. However, they did include an entirely plausible list of measures, including a number of different ways of measuring musical training and experience, and a couple of measures of pre-existing traits.

Of the three variables in the predictive equation, two were pre-existing (gender and perfect pitch) and one was a function of training (exam at grade 6 level or not). In all three cases, the effect sizes were small and the model should not be taken as indicating any strong effects. The largest of the three effects was an estimated difference of 1.65 units, comparing those with perfect pitch to without perfect pitch, after adjusting for gender and exam at grade 6.

In summary, from the measures of musicians’ training and pre-existing traits used in this study, melodic pattern audiation (as measured by the MET) can be predicted to only a small degree.

**Tonal Understanding**

**Question 5: To what degree do trained musicians understand heard tonal music?**

The melodic pattern audiation discussed above is an important step to more advanced stages of TU. In order to address the question of the degree to which participants understand tonal music, it is necessary to establish a reference point for difficulty level of the MTT. The previous chapter examined pattern audiation difficulty created by certain structural elements of melodies. One approach to estimate the difficulty level of the transcription task is by analyzing the structural features of the melody.

**MTT Melody Structure And Degree of Difficulty**

Figure 36 shows the music transcription task with the melody completed (shown here in large brackets). Note that the first two bars and last two bars of the melody were already notated on the test sheet. The rhythm was also indicated above the stave.

The MTT melody is a reconfiguration of six notes of a Western Bb major scale. The excerpt consists of two separate sections: bars 3-4 and 6-8. The scale tones of the first section are 6-1-6-5-4-5-6; those of the second section are 3-5-4-6-1-2-1. The intervals are simple diatonic ones. The excerpt begins and ends on the tonic and does not exceed the range of an octave. There are no non-scale tones or large leaps. These are the same set of notes of Twinkle Twinkle Little Star and countless other tonal melodies.
Scale steps and movement in thirds are the most common sequences in Western music. The MTT melody notes are the rudiments of Western scales, melodic patterns which most participants are likely to have played many thousands of times. When considered against these structural factors, the MTT melody is relatively simple.

In addition to the structural simplicity of the melody, the task is further simplified by the indication of the rhythm above the stave, which removed the need to calculate the rhythmic aspect of the task. The task required transcribing only a single melodic line, rather than multiple voice parts. In addition to this, the melody is at a slow tempo, and participants heard it six times, with pauses. The melody is also simple when considered in relation to the highly complex repertoire most participants are capable of playing, as indicated by their examination grade levels.

**Calculating MTT Degree of Difficulty**

In line with an apparent limited interest in audiation generally, there are no published investigations of how to assess aural skills (Karpinski, 2000). In the specific area of melodic transcription, published textbooks with guidelines or principles for assessing transcription tasks are rare (Karpinski, 2000). However, some aspects contributing to transcription difficulty have been identified by Butler and Lochstampp (1993:11). These include:

- number of notes in the melody
- size of leaps
- direction of leaps (descending more difficult than ascending)
- chromatic tones (more difficult than diatonic tones)
- leaps to chromatic tones

Figure 36: MTT With Melody Completed
On the basis of these factors, Butler and Lochstampf (1993:12) tentatively proposed a difficulty index for rating transcription tasks that, while not scientifically validated, is functional and can be applied systematically as indicated as follows.

<table>
<thead>
<tr>
<th>Transcription Criteria</th>
<th>Points (+/-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Each melody note</td>
<td>+1</td>
</tr>
<tr>
<td>Ascending leap &gt; Major 3</td>
<td>+1</td>
</tr>
<tr>
<td>Descending leap &gt; Minor 3</td>
<td>+2</td>
</tr>
<tr>
<td>Chromatic alterations (except 5 &amp; 6 in minor)</td>
<td>+2</td>
</tr>
<tr>
<td>Leap to chromatic alteration</td>
<td>+3</td>
</tr>
<tr>
<td>Tonal sequence</td>
<td>-2</td>
</tr>
<tr>
<td>Parallel antecedent-consequent phrase</td>
<td>-4</td>
</tr>
</tbody>
</table>

Applying this index to the MTT yields the following difficulty rating:

<table>
<thead>
<tr>
<th>MTT Criteria</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melody notes</td>
<td>14</td>
</tr>
<tr>
<td>Ascending leap</td>
<td>Bar 3: D up to G</td>
</tr>
<tr>
<td>Descending leap</td>
<td>Bar 6: G down to D</td>
</tr>
<tr>
<td></td>
<td>Bar 7/8: G down to Bb</td>
</tr>
<tr>
<td>Chromatic alterations</td>
<td>None</td>
</tr>
<tr>
<td>Tonal sequence</td>
<td>Bar 6, 7 ascending 3rds</td>
</tr>
<tr>
<td>MTT total difficulty rating</td>
<td>17</td>
</tr>
</tbody>
</table>

Lochstampf and Butler (1993) further suggest an approximate measure of expected transcription competence for tertiary level music students in the US.

<table>
<thead>
<tr>
<th>Tertiary level (US)</th>
<th>Expected Difficulty Rating Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start of 1st year</td>
<td>8-12</td>
</tr>
<tr>
<td>End of 1st year</td>
<td>25 approx.</td>
</tr>
<tr>
<td>Start of 2nd year</td>
<td>20 max.</td>
</tr>
<tr>
<td>End of 2nd year</td>
<td>40-50</td>
</tr>
</tbody>
</table>

The difficulty rating of 17 for the MTT positions it somewhere in the expected competency range of the end of first year and start of second, at least in the United States music education system. It is well below the expectations for students at the end of their second year of tertiary training (40-50). By these standards, the MTT task is relatively simple.

**International Comparisons**

Another way of gauging the relative difficulty of the MTT is by comparing it to expected transcription capabilities in other countries. Transcription tasks are widely used in formal music education around the world to estimate TU in candidates for entry into music courses. In Hungary, for entry into the Music High School (known as Conservatorium), students of about 12 years of age are expected to be able to transcribe an 8-bar single-line melody, and a two-part Classical melody,
in a single listening. Also in Hungary, at tertiary level, entry into a BMus requires candidates to transcribe: 4-part Bach chorale (8-bars); 2-part Classical melody (16-bars), single-line 20th century melody (8-bars); two- three- and four-part harmonic progressions (Liszt-Ferenc Academy 2014; Mónika Benedek, personal communication).

At the Kodaly Pedagogical Institute in Kecskemet, foreign teachers are graded into aural classes by a transcription task. One such task used the first eight bars of the violin part of Bartok’s 2nd Violin Concerto played several times (G. Howell, personal communication). In Holland at the Rotterdam conservatory, the entry exam for the BMus in popular music includes a transcription task using a three-minute excerpt of chamber music. Students are given the starting note and are asked to transcribe as much as possible of all instruments in several listenings (Eric Budd, personal communication). Entry into some elite composition courses requires candidates to transcribe excerpts of string quartets as they are being performed live in the same room (Richard David Hames, personal communication).

To gauge the difficulty level of these overseas comparisons, applying the Butler and Lochstampfor, (1993) difficulty index to the Bartok excerpt yields the following difficulty rating:

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total notes</td>
<td>42</td>
</tr>
<tr>
<td>Ascending skip &gt; Major 3 (x8)</td>
<td>8</td>
</tr>
<tr>
<td>Descending skip &gt; Minor 3 (x7)</td>
<td>14</td>
</tr>
<tr>
<td>Chromatic alterations (1)</td>
<td>2</td>
</tr>
<tr>
<td>Difficulty level:</td>
<td>66</td>
</tr>
</tbody>
</table>

In comparison to this, the MTT rating of 17 is at the low end of the difficulty range.

For the purposes of responding to the research question, the overall results of the MTT were reduced to two categories: those indicating TU and those indicating no TU, as described in chapter 7. After reducing the data in this way, the analysis of overall results indicated the following:

- 12% of the tertiary musicians successfully completed the secondary school task.
- 72% did not understand the tonal melody after six hearings.
- 39% were limited to representing only melodic contour for two consecutive bars or more.
- 60% were unable to correctly identify melodic contour for more than two consecutive bars.
- 21% of tertiary trained musicians were unable to represent any contour correctly.
- Many musicians lacked understanding of the elemental scale steps of the melody.
- Many musicians were unable to infer a tonal centre in the heard melody.
CHAPTER 8: DISCUSSION AND CONCLUSIONS

The almost identical rates of TU in the secondary and tertiary groups is noteworthy. Audiation in secondary students has been regularly cited as an area of weakness (VCAA, 2015). It has been noted, for example, that many secondary music students at the end of their training are still unable to recognize the first interval of the national anthem (Perfect 4th), and unable to hear stepwise melodic movement (VCAA, 2012).

In view of the perceived limited audiation development at secondary level, the similar results at tertiary level are noteworthy. There is no evidence in the results of this study to suggest that tertiary training has made any improvement on the TU of music students.

The simplicity of the task, as compared with overseas expectations, and established difficulty criteria suggest that the degree to which trained musicians understand tonal music is relatively limited. These findings appear to confirm and clarify the numerous inferences and claims in the literature, and anecdotally, that many trained musicians have limited TU (Green, 2002; Seymour, 1910; Gordon, 2007; Gruhn, 2006; Bridges, 1984; Williams, 2007; Leong, 1999).

Question 6: What degree of association exists between TU and melodic pattern audiation?

The limited TU shown by most of the trained musicians at tertiary level seems striking. One obvious explanation would be that the results reflect problems not with TU, but with the skill of notation. The significant association between the MET results and MTT results provides valuable support that this is not the case. The general trend across the results on both tests was that poor performance on one was correlated with poor performance on the other.

In addition to this, a cursory examination of participant background information suggests a widespread lack of notation skills was unlikely. Almost all participants (97%) had received instrumental music lessons. As only a small percentage (12%) said they learned mainly by ear, it is almost certain that lessons involved varying extents of reading from notation. Further to this, almost half the participants (45%) learned music mainly by looking at notation. A further 43% learned with a combination of notation and ear. Almost half (43%) had done music examinations of at least grade-6 and up to level 10. These examinations are usually based almost exclusively around learning from notation. Most participants (80%) had also studied music as a secondary school subject. This also suggests knowledge of notation to at least some extent. Additionally, almost all (92%) had completed or were completing a BMus. It is most likely that notation was a large part of tertiary training. From this information it seems unlikely that a large proportion of the sample lacked the notation skills necessary to translate a simple heard melody.
The association between melodic pattern audiation and TU suggests that the poor results indicated by the notation task are not necessarily attributable uniquely to poor notation skills. Rather, this points towards limited TU among trained musicians.

**Question 7: What degree of association exists between TU and musical training?**

The previous analysis of melodic pattern audiation showed almost no association between the extent of formal music training and melodic pattern audiation. That trend continued in the analysis of TU. One of most interesting results from this study is that the extent of a musician’s training was not significantly associated with TU. In predictive modelling, after accounting for all other background variables, there was no evidence that the extent formal training experienced by the musicians in this study had contributed to their TU.

Effectively, this means that many years of learning to play an instrument, including at least six years or more of preparation for exams, lessons and associated practice and performance, did not appear to have an impact on the ability of musicians to understand a simple tonal melody heard six times. Nor did any particular type of teaching method, nor learning a particular instrument appear to improve that ability. Further, numerous years of learning an instrument at secondary school, followed by training at the tertiary level did not appear to significantly improve TU.

About a quarter of the BMus participants (28%) showed TU. This is almost the same as the original 2001 secondary students, whose corresponding figure was 30%. The similarity of scoring between the two groups supports the idea that tertiary training has not improved the ability to successfully complete a TU task designed for secondary school students. As this present study represents a survey of the current state of audiation in Australian music students, it is not possible to speculate on whether tertiary students in 2001 might have performed any better or worse. This lack of evidence for an effect for extent of training is interesting when considered in relation to the widespread assumption in the literature that audiation can be developed through appropriate learning strategies.

The two training variables remaining in the predictive model were “type of music” and “way of learning”. For the first of these, the odds of TU for classical musicians were estimated to be almost twice as high as for the combination musicians. The advantage for classical musicians increased to almost ten times as high when compared to the popular musicians.

By far those least likely to have TU were the popular musicians no matter how they learned. The popular musicians without the benefit of perfect pitch showed a very low probability of TU, ranging from zero to a maximum of 10%. The limited TU in the popular musicians is an important
finding of this study. It is in strong contrast to the claims in the literature, and anecdotal evidence, that popular musicians are more likely to have superior TU compared to the classical musicians.

The other training variable remaining in the model, “way of learning” was a less convincing predictor of TU. Analysis of background information showed that about half the participants (45%) learned mainly by notation, and about half (43%) using a combination of notation and ear. Relatively few people learned mainly by ear. This small proportion of aural learning, in what is widely regarded as an aural art, is in itself interesting, and this information confirms the dominance of notation in most formal music education.

It is particularly noteworthy that of the few people who do learn aurally, hardly any show TU. Those who learned mainly by ear had a very low probability of having TU. This is also an unexpected result. The very small percentage of ear learners with TU is interesting as it seems contrary to inferences in the literature that ear learners would have advantages on this task. This result may be partly due to the small sample size: 42 or 12% of participants learned by ear. Learning from a combination of notation and ear was most significantly associated with TU. Overall it was the classical musicians, learning from notation or a combination who were most likely to have TU.

**Question 8: What degree of association exists between TU and pre-existing traits?**

Pre-existing factors, existing outside of musical training, were most strongly associated with TU in trained musicians. These were gender, language and perfect pitch.

As expected, possession of perfect pitch was by far the most important factor in TU. For those with perfect pitch, the odds of TU were 13 times greater than for ordinary musicians. Without the benefit of perfect pitch, the rate of TU in highly trained musicians seems strikingly low. As perfect pitch is thought to occur outside of musical training, this result again calls into question the role of current formal music training in developing TU.

More surprising is the fact that the odds of TU for Asian language speakers were estimated to be almost five times higher than for the non Asian speakers. It is an important finding of this study, that the advantage in TU for Asian speakers is present even after adjusting for the variable of perfect pitch. This effect on TU for language group is interesting and would benefit from further investigation.

The finding that gender provides an advantage in TU is also interesting. The odds of TU for males were estimated to be twice as high (2.1) as for females, after adjusting for the other variables in the model. Although gender is a less convincing predictor of TU, this is an intriguing result as there is no immediate explanation for why gender should provide an advantage in TU. Further research to investigate potential reasons for this could provide valuable information about audiation development in musicians.
Question 9: To what degree can TU be predicted from a musician’s training and pre-existing traits?

The predictive model for TU developed in this analysis has shown the degree to which the training and pre-existing variables are most likely to be associated with TU in trained musicians. The univariate associations with TU give a limited understanding of the true pattern, because of confounding between them. The most reliable indication therefore comes from the logistic regression model, since it simultaneously allows for all relevant variables.

Unlike the situation for the MET, in which relationships between the outcome and the predictors were not strong, there are some marked relationships between TU and the explanatory variables measured in the survey. The key results are shown in Table 25.

Table 25 reports the result of a model selection exercise in which all candidate variables were initially considered, and non-significant predictors were successively removed (namely, backward elimination).

The strongest predictors, as indicted by both the size of the odds ratios and the levels of statistical significance, were perfect pitch and type of music played.

For perfect pitch, the odds ratio was 12.9, with a 95% confidence interval of (4.0 to 41.8): those reporting perfect pitch had a far higher level of TU than those without, even after adjustment for gender, language group, type of music played and main way of learning.

For type of music played, there was a strong indication that “classical” and “mixture” each showed higher levels of TU than “popular”, and these differences were not accounted for by gender, language group, perfect pitch or main way of learning. For example, the adjusted odds ratio for ‘classical’ relative to ‘popular’ was 9.4, with a 95% confidence interval of (3.3 to 26.3).

The next strongest predictor of TU was language group; those reporting an Asian native language had an adjusted odds ratio for TU that was 4.9 times higher than those reporting any other native language (95% confidence interval: 1.7 to 14.2).

Finally, there were two variables that were significant predictors, each with a P-value of 0.02. This P-value is less than the conventional threshold of 0.05, but given the number of comparisons involved, the conclusions for these variables should be more qualified. In the case of gender, the adjusted odds ratio for TU for males compared to females was 2.1 (95% confidence interval: 1.1 to 3.8). The markedly different unadjusted and adjusted results for gender are discussed above in the sub-section “Simpson’s Paradox”.

In the case of main way of learning, there are some large adjusted odds ratios, despite this, the P-value is not very small, due to the small numbers in the ear category in particular.

One way to get useful insights in the finding of the logistic regression model is to examine the estimated probabilities of having TU; for each combination of the explanatory variables used on
the model. These are shown in Table 26, expressed as percentages. For example, (underlined in the table) for female subjects with an Asian language who do not have perfect pitch, play mainly classical and learned by notation, the predicted percentage of TU based on the model is 62%. In the actual dataset, there were seven such subjects, four of whom had TU, an actual percentage of 57% (= 4/7). Note that although Table 26 only shows percentages for those categories that were present in the study, the model is able to determine the estimated probability of TU for any of the categories of the table.

The very strong effect of perfect pitch, for example, can be seen by comparing any percentage in the left hand side of the table (perfect pitch = ‘yes’) with the corresponding percentage in the right hand side (perfect pitch = ‘no’). For example, expanding on the example used above: while female subjects with an Asian language group who do not have perfect pitch, play mainly classical and learned by notation have a predicted percentage of TU of 62%, female subjects with an Asian language group who do have perfect pitch, play mainly classical and learned by notation have a predicted percentage of 95%.

In summary, on the evidence from this survey, TU can be predicted strongly by perfect pitch, type of music played and language group, and less convincingly by gender and main way of learning.

Discussion

Music Literacy

The broad theme underlying this thesis was the question of what is the best way to become an expert musician. The findings of limited TU presented above have important implications for a discussion of music performance expertise. This thesis began by reviewing numerous claims relating to the notion of musical literacy. One of the major rationales for the current formal approach to acquiring music performance expertise is that the ability to use the symbols of notation to generate musical performance is assumed to be evidence of musical literacy. Although it is a widely used term, it was suggested that there was confusion surrounding the concept. It was claimed many musicians who use notation may not be audiating, understanding what they are reading, but rather are decoding, restricted to using the visual symbols of notation as cues to generate sounds on the instrument (Bartel, 2006; Bridges, 1984; Gordon, 2007; Gruhn, 2006; Lehmann & Davidson, 2002; Seymour, 1910; Waller, 2010). It was an important part of this study to investigate whether musicians have notational audiation, the ability to tonally understand what they are seeing in notation.

The results of the test for TU showed that without the benefit of perfect pitch only one out of five tertiary musicians was able to convert a heard simple tonal melody onto notation. These results provide some empirical evidence in support of the claims that many musicians may not be audiating
what they are seeing in notation, and are therefore not truly reading. Rather, they may be reliant on decoding, using the symbols of notation as a visual guide to note production or other non-audiation representations to generate recitation. This finding may be of some interest to music educators because notational audiation has been described as “arguably the most important goal we set for our students” (Karpinski 2000b). These findings provide some empirical evidence that this important goal is perhaps not being achieved.

**Distinct Underlying Representations.**

The finding of widespread limited ability to understand a simple tonal melody and transfer it into notation is in stark contrast to the high level executive skills that most of the musicians obviously possess. This finding appears to indicate that many of the musicians have highly developed mental representations that are not based on audiation.

As discussed previously in this thesis, the concept of distinct mental representations for types of knowledge has become a key notion of skill acquisition. Expertise is thought to be founded on the ability to generate and maintain mental representations. In music, Gruhn (1997), investigated how different kinds of mental representations affect music performance and learning. Results confirmed the existence of representations based on audiation as well as representations based on knowledge about music. Gruhn found that the audiation representations remained more stable over time, and only audiation representations are internalized and stored in the neural network in a way that works efficiently and economically (Gruhn, 1997:45). Gruhn refers to audiation-based representations as “genuine” musical representations to distinguish them from non-musical representation such as kinaesthetic representations, or representations of theoretical knowledge.

Others observe this distinction. Serafine (1988) confines the definition of music to only mental representations involving audiation. In particular she excludes knowledge about music, such as theoretical or technical knowledge, and decoding of notation and motor coordination. In composition and improvisation, Serafine also excludes from the category of music, any algorithmic, rules-based approaches to creating a musical performance. “All these activities are specifically excluded from the category of music proposed here because they rest on thought processes, of whatever necessity, integrity, or desirability, that are nonauditory” (Serafine, 1988:72).

Background information collected from participants suggested that the musicians had generated and maintained representations for some kinds of instrumental music performance. The simplicity of the transcription melody is likely to be in contrast to the complex, technically demanding repertoire that most tertiary music students are capable of reciting, or improvising. It is also likely that the musicians have representations for the theoretical elements of the transcription melody. If the melody had been presented visually, in notation, most of the musicians could have named the notes,
CHAPTER 8: DISCUSSION AND CONCLUSIONS

and known how to play them relatively effortlessly on an instrument. In this sense the participants have generated numerous kinds of representations for instrumental music performance expertise. It is a major finding of this study, however, that once the information of the melody was presented as sound, most of the highly trained musicians had difficulty understanding the most fundamental elements of the Western major scale. Numerous highly skilled instrumentalists did not tonally understand the same scale steps and sequences that they have played since they were beginners. To use an analogy from language, these sounds were as easy as A-B-C.

This finding appears to provide some support for many of the claims such as Gordon (2001:1) who suggested most formally trained musicians are effectively musically illiterate: “Essentially, they only decode, not truly read, simply by pushing keys or valves on an instrument. The analogy is knowing the alphabet but not being able to give meaning to written words or sentences” (Gordon, 2001:1). The finding also supports many other similar claims (Gruhn, 2006; Schleuter, 1984; Woody & Lehmann, 2010; Lehmann & Davidson, 2002; Bridges, 1984).

This contrast between the highly advanced theoretical knowledge and technical skills of the participants (as suggested by their learning backgrounds) and their limited ability to understand the tonal melody presented aurally suggests that for many trained musicians, audiation representations are not highly developed.

The pervasive assumption that recitation is equivalent to music performance expertise may mean that these findings are of limited significance to many music educators. This is because recitation can be achieved without the need for audiation. The findings of this study are in a sense proof of this. Many of the participants are evidently experts in the art of recitation, while lacking in audiation.

Improvisation can also be approached without the need for audiation (Johnson-Laird, 2002). The findings of the TU skills of the popular musicians in this study provide a potentially important element for discussion.

**Ear Learners and Popular Musicians**

One of the most important aims of this thesis was to investigate claims that some approaches to learning and performing music might be more strongly associated with audiation development than others. One of the more interesting findings of this study was the limited TU shown by the popular musicians and those who learned mainly by ear. Only 6% of the popular musicians showed TU compared with about half of the classical musicians. And only 5% of ear learners showed TU compared with about a third of notation learners. These findings are interesting because they provide empirical evidence that is contrary to expectations generated in the literature and anecdotal evidence that
suggested popular musicians and ear learners should have performed significantly better on the TU task (Green, 2002; Woody & Lehmann, 2010).

The basis for those claims is that most popular musics have traditionally been associated with listening-copying practices with a minimal use of notation. This is thought to develop effective audiation (Green, 2002; Woody & Lehmann, 2010). Yet the popular musician and ear learners in this study showed by far the weakest TU. Certainly, in this study, there was no sign of the “very good ears” of the popular and vernacular musicians portrayed in the literature (Green, 2002).

The small percentage of ear learners in this study is interesting in itself, when considered against the idea of music as an aural art. Only 12% of participants learned by ear. Out of the total sample, only two of the classical musicians learned by ear and one “mixture” musician. The large majority of ear leaners were popular musicians and most (80%) of these were drummers, pop singers and guitarists. These kinds of musicians may not be as familiar with notation as some of the other musicians and this may suggest they were disadvantaged by the notation skills required by the MTT. This was not supported by the comparison of the notation task with the non-notation task. A significant correlation for the two tests of audiation was found. This suggests the poor levels of TU were not necessarily a consequence of limited notation skills.

The possibility that this was a problem with notation, however, was supported in some way by the results on the non-notation test (MET). On this test, without the need for notation skills, the ear learners performed just as well as the other groups. In further modelling, way of learning was not found to be a significant predictor of melodic pattern audiation.

The results that showed limited TU for the popular, and ear musicians, may reflect one of the limitations in the data collection. This relates to the ability of the questionnaire to adequately provide precise information on all variables. Due to time constraints of the testing procedure, it was beyond the scope of this study to establish precise measures of the type of music played, and main way of learning. The questions are necessarily open and imprecise and the information gathered was intended to provide some guide to these variables, rather than an exhaustive measure. It is therefore not possible to accurately know to what extent people played “mainly” by ear, or “mainly” played popular music. This may have led to a distorted picture of audiation in the popular and ear groups.

An important question raised by these results is the extent to which a musician would be able to be creative and expressive, without the ability to audiate and tonally understand a short simple melody that they have heard six times. Although there are numerous problems associated with trying to measure improvisation in music performance, further research would be interesting to try to investigate whether there is an association between audiation, and a performer’s ability to spontaneously create a music performance.
Another possible explanation for the poor TU shown by the popular and ear musicians could relate to an observation that once popular musics are absorbed into formal music education, the learning and teaching of those musics changes markedly (Green, 2002; Woody & Lehman, 2010). Of particular note, is that the traditional listening-copying basis for these musics is lessened or disappears, and learning and teaching often resembles the conventional approaches of recitation practices (Green, 2002; Woody & Lehman (2010). It is necessary to note carefully here, that although musicians in this study may have played popular music, the fact that they were operating within the formal music system automatically made them not strictly speaking, the popular or vernacular musicians cited in the literature, who operate outside of academia.

The teaching of improvisation in most formal education systems in Western cultures occurs primarily within the jazz idiom. Although this has traditionally occurred via a listening-copying approach, presently within formal education, the most widely used approach to learning is an algorithmic rules-based approach known as the chord-scale method (Kenny & Gellrich, 2002:126). In this method, choice of what note to play is influenced in part by intellectual choices and decisions concerning the harmony of the chord sequence (127).

Numerous criticisms have been directed towards non-audiation based approaches to improvisation and composition ranging from the inhibiting influence on improvised response, mechanical performances, “knee-jerk reaction” which “ultimately only produces a frantic and disconnected style of playing”, and lack of artistic individuality (Kenny and Gellrich 2002: 127).

The finding that the popular musicians have relatively limited TU is significant because it provides some support for claims that the many popular musicians may not be audiating what they are playing, but may be approaching improvising, and composition, from an algorithmic approach, that is, by using rules and formulas, and other non-audiation cues to generate musical sounds.

It is interesting to speculate that the limited audiation shown by the popular and ear musicians in this study, may be a reflection that once integrated into formal music institutions, the development of audiation in popular musicians is reduced.

Despite these formal approaches to recitation and improvisation, numerous authors continue to question the extent to which some aspects of performing music are genuine musical skills. Gardner, (1995:802) for example makes a clear distinction between “genuine expertise” and “simply high-level drill”. Others make a similar distinction between learning genuine musical skills, in contrast to “executive” skills (Williams, 2007; Sloboda 2005; Gruhn, 2006; Gordon, 2007). Increasingly, researchers and educators are questioning the assumption that the ability to recite music, or improvise from algorithms, comprises the full spectrum of music performance expertise. As Dobbins (1980:37) notes, reading a famous literary work does not imply creativity in a language, nor does reciting a sonata, or transcribed jazz solo indicate creativity in music.
A related finding from the handwritten responses on the test for TU may provide an important contribution to this discussion.

**Read-only Literacy**

The quality of notation writing on many of the responses on the MTT was poor, and in some cases bordering on elementary. This was the case even for very highly trained musicians (See for example Figure 30). This finding is interesting in relation to Waller’s (2010) claims about what he has termed a culture of “read-only” music literacy. Waller (2010) observed that what is almost always missing from definitions of music literacy is the act of writing music. The concept of musical literacy is discussed almost exclusively in relation to the reading of notation. The idea of music notation as something one actively writes is “conspicuous by its absence” (Waller 2010:30).

As Waller notes, although instrumental learners are from the beginning expected to read notation, it is rare that they are asked to write even the most simple melody from memory onto a blank staff. This is in contrast to many other disciplines such as mathematics, chemistry and logic, where students are required to not only read, but to write fluently in the relevant symbol systems (Waller, 2010:27). Waller (2010) and Bartel (2006) point out that this situation is in stark contrast to training in language literacy which involves both reading and writing from the early stages. They suggest that this is evidence of a profound difference between music literacy and language literacy, a difference which may not be well understood by many educators.

In terms of the analogy with language literacy, it would be considered anomalous that someone at the tertiary level could barely form letters and words. Yet this was the case with many of the responses from highly technically skilled musicians in this study. In the case of the violinist with many years of training (see Figure 30), including a completed BMus and very high level examination, to describe this person as musically literate may be questionable.

The data collected in this study on the quality of notational skills in highly trained tertiary musicians provide strong support for Waller’s claims that many musicians, if they have notational audiation at all, may have acquired read-only notation skills. The findings of limited TU suggest that it may be appropriate to reconsider the widespread use of the term “literate” in musical contexts.

**Implications Of Read-only Literacy**

The concept of read-only music literacy has some potentially important implications for this present discussion. Waller (2010) has drawn strong parallels between read-only literacy in language and in music. He cites numerous historical practices where colonizing powers and slave owners used read-only language literacy to deliberately deprive minorities the power of self-expression and communication. Waller (2010:27): proposes that there may be important parallels in formal music
education, where the widespread culture of read-only notational literacy is a way of “teaching them how to take orders”, disempowering learners, rendering them passive rather than active, and leading to a culture of reproduction rather than artistic creativity (Waller 2010:40).

The issue of student empowerment and creativity has become an increasingly important topic across many areas of education (Andreasen, Nancy (2006). Creativity is seen as one of the most valuable commodities that people will need to face the challenges of life in the twenty-first century (Andreasen, 2006; Robinson, 2006). A growing body of literature questions the relevance and effectiveness of the recitation approach to instrumental music education because it fails to address issues of creativity and student empowerment (Regelski, 2006; Williams, 2007; Gruhn, 2006). This is important for this present discussion because many of the criticisms of formal music education centre around a failure to develop effective audiation in learners, a claim that appears to be supported by the findings of this present study.

Despite highly organized approaches to learning to play an instrument, many researchers are puzzled that so few people develop any significant level of music performance expertise (Sloboda, 2005:275; Williams 2007:21). Learners are left with a limited range of musical skills often likened to being restricted to rote learning phrases from a tourist phrase book (Gordon, 2007; Williams, 2007; Bridges, 1978). This leaves learners with difficulties in learning and performance and a lack of creativity. Bridges summarizes some of the outcomes of the formal approach:

Hundreds of thousands of people in this country have battled their way through piano and theory exams, and emerge at the end of their school days unable to play fluently (let alone sing) at sight, still dependent on a teacher to tell them if they are playing wrong notes, unable to improvise, or even to remember the four pieces they learnt for the exam last year. (Bridges, 1984:71)

Many students lose interest as indicated by the high rates of attrition from formal music education programs. Almost everyone who tries to learn an instrument this way gives up after a few years (Green, 2002; Sloboda, 2005; Williams, 2007; Pascoe et al., 2005). The skills learned often do not continue to be useful to students once they leave formal training (Gordon, 2007; Gruhn, 2006; Williams, 2007; Bridges, 1984; Green, 2002). As Williams (2007:21) describes it, “Our society is littered with adults who played a musical instrument once upon a time”.

High attrition rates are unlikely to be unique to instrumental music, and presumably occur in many other academic and sporting areas. The reason why attrition from instrumental music programs is important for this discussion, is that many of the problems identified in the current approach to acquiring instrumental music performance expertise centre around a lack of audiation. Lack of audiation is thought leave learners with difficulties in learning and performance, including
being limited to rote learning what is written, and without the fundamental musical ability of spontaneous musical expression (Bridges, 1984; Dobbins, 1980; Gordon, 2007; Gruhn, 2006; Woody & Lehmann, 2010). There are claims that this may be limiting enjoyment, and thus motivation and engagement for music learners (Gordon, 2007; Green, 2002). The findings of this study therefore have the potential to provide a contribution to the literature on this issue, because they have identified widespread limited TU in many formally trained musicians.

Problems within formal music education are perceived by some observers to be serious enough to warrant calls for “deep educational reform” (Cerqueira, Zorzal, & de Ávila, 2011), “a very basic change in our pedagogical approaches” (Gruhn, 2006) and a “rethinking of our music education system from top to bottom” (Bridges (1978).

**Genuine Music Performance Expertise**

One of the major causes of concern among those calling for changes to formal music education is the limited scope for creativity provided by the process of music recitation. There are growing calls among educators for the need to return to the traditional conception of music performance expertise that encompasses spontaneous musical expression and creativity (Green 2002; Haroutounian 2000; Dobbins, 1980; Gordon, 2007; Gruhn, 2006; Sawyer 2007; Dalcroze;1928). This traditional conception of music performance expertise is based on the notion of music as a kind of language. In place of speech, improvisation becomes “the spontaneous expression of musical images that directly reflect the immediate ideas, emotions, and sensations of the improviser” (Dobbins, 1980:36).

So pervasive has the recitation approach become, that there is a perceived lack of vocabulary to describe this traditional, expressive and creative mode of music performance expertise. In Germany, in the debate on the goals of music education, it was found necessary to introduce a word specifically to define this kind of music performance expertise. The term “musicalization” (Musikalisierung) was used to indicate “the very basic ability to act musically; that is, analogous to language where one acts verbally” (Gruhn, 2006: 24).

The calls for a return to traditional music performance expertise are particularly important for this discussion because spontaneous musical expression is founded on the development of genuine musical representations based on audiation.

**Genuine Music Expertise And Audiation**

Gruhn (2006:13) found that at a neurobiological level, it is necessary for audiation representations to be developed before they can be activated for creative musical processes. Genuine music learning in this sense refers to audiation development: the process of establishing audiation-based representations of musical information. Once a representation for a particular
musical sound (such as a melody) is formed, it can be activated while listening and recognizing a sound as that melody. This activation can occur while listening, playing, improvising, creating, notating, reading, or imagining music. The foundation for and the process of that activation is the ability of audiation (Gruhn & Rauscher, 2002, 2007).

Numerous authors cite the essential role of audiation in the traditional model of music performance expertise (Bridges, 1984; Dobbins, 1980; Gordon, 2007; Green, 2002; Gruhn, 2006; McPherson, 2005; Peggie, 1985). Gordon stresses that audiation is “the foundation of musicianship” (Gordon, 2009) and that in order to be able to create and improvise, students need to have developed audiation abilities in order to “know what they might want to say musically”. Webster (1990:23) describes audiation as not only important for recitation “but is also critical for creative thinking ability and specifically for divergent tasks”. McPherson (2005:10) has argued that it is “especially important” that children develop audiation in order to represent what they wish to create on their instrument.

The fundamental role of audiation in traditional music performance expertise is particularly relevant to this discussion, because the empirical evidence gathered in this study suggest that audiation is limited in many formally trained musicians. This provides some support for numerous claims in the literature that many trained musicians may be poorly equipped to engage in the traditional expressive and creative music skills that are increasingly called for by musicians, researchers and educators.

Implications For Current Practice

Genuine Music Learning

The previous section established a distinction between types of music performance expertise which have been described as genuine expertise, in contrast to drill or executive skills. Genuine expertise corresponds to a musician’s ability to audiate musical sound in order to express it spontaneously on an instrument or notate it, as well as to recite from notation. This is in contrast to music performance without audiation, such as rote learning by decoding from notation, or using algorithms to generate improvisation or composition.

Numerous authors stress the importance of developing genuine music performance expertise based on audiation. There are numerous claims that most formal music education emphasizes the development of executive skills and theoretical information and neglects the development of genuine audiation expertise. The results of this study provide some empirical evidence to support these claims. The findings of this study may also provide an important contribution to the literature relating to the recently developed Australian curriculum. This document echoes the widespread calls for a return to the traditional view of music performance expertise.
The Australian Curriculum
The Australian Curriculum (ACARA, 2015) is aimed at standardizing across all Australian states and territories the expected teaching and learning outcomes for school students up to Year 12. The learning and teaching guidelines for each academic subject involved extensive consultation with a wide range of stakeholders. Teachers and principals, state education authorities, professional education associations, business, industry, community groups, general public and all governments are involved in the development of the guidelines. The guidelines for each subject take several years to develop and are based on thousands of submissions from individuals groups and organizations. National and international research also informs the process and as does input from overseas curriculum bodies on international best practice expectations (ACARA, 2015).

The music section of the Australian curriculum is subsumed under the section on the Arts. Because of the recent nature of the Arts section, the guidelines for the music curriculum are currently still only finalized up to year 10. The Australian music curriculum is highly relevant to the question of what is the best way to become an expert musician. The document describes what instrumental music performance expertise is, and the best way to achieve it.

Traditional Music Performance Expertise
The input from an extensive range of stakeholders in music education resulted in a curriculum document that describes the traditional view of music performance expertise discussed above. Music is considered an expressive art form and expertise is founded on enabling creativity and musical expression via spontaneous music expression and composition (ACARA, 2015).

The notion of empowering music learners to become creative and expressive individuals is woven throughout the document. Learners should acquire “the confidence to be creative, innovative, thoughtful, skilful and informed musicians” (ACARA, 2015:38). Skills and techniques learned should allow students to “manipulate, express and share sound” (ACARA, 2015:38). Specifically, the aims of the Australian music curriculum are to empower musicians with the skills necessary to compose, perform and improvise (ACARA, 2015:38). Noteworthy for this discussion, a specific guideline suggests that learners should be able to notate the music that they hear (ACARA, 2015:40).

Music Expertise Based On Audiation
The optimal way to achieve these aims is foreshadowed in opening statement of the curriculum rationale: “Music is uniquely an aural art form” (ACARA, 2015:38). Central to the process of acquiring creative music expertise is the development of audiation. As with most of the literature of its kind, audiation is referred to here as “aural skills”, “listening skills”, “ear training” and “aural understanding”.

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Aural skills are described as: “particular listening skills students develop to identify and discriminate between sounds in music (ACARA, 2015:40).

The document is unequivocal about the fundamental importance of audiation in acquiring creative music performance expertise: “Learning in music is aurally based and can be understood without any recourse to notation” and “aural skills development is essential for all listening, composition and performing activities” (ACARA, 2015:38).

There is a very clear consensus between the guidelines of the Australian music curriculum, and the many calls discussed above for a return to a traditional view of music performance expertise.

**Implications for Secondary Music Education**

The core aims and guidelines of the Australian curriculum document are highly relevant to this study, because most of the participants (80%) studied music as a Year 12 subject at an Australian secondary school. This generally implies several additional years of prior study. All participants had graduated to music training at the tertiary level and many had already completed tertiary music training. Yet only a small proportion of the musicians were able to “identify and discriminate” between sounds in music. Most of the musicians were unable to understand a short, simple, tonal melody heard six times. Without the benefit of perfect pitch, the figure is one in five. Almost two-thirds of these secondary and tertiary trained musicians had difficulty notating even the melodic contour for two consecutive bars. Many were unable to achieve this. The fact that most of the participants had undergone secondary and tertiary training suggests they were familiar with notation.

When considered in relation to the Australian music curriculum, the findings of this study contribute importantly to the literature, because they provide some empirical evidence to suggest that the core aims and expectations of Australian curriculum are far from being achieved.

An additional implication arises from the results of this study. The central pillar of the Australian music curriculum is that music performance expertise includes creativity and spontaneous musical expression, and that this is achieved through audiation. If, as the results of this study suggest, there is limited audiation in many formally trained musicians, the question arises as to what extent Australian-trained musicians possess the necessary skills to engage in the kind of self expression and creativity of traditional music performance expertise.

The results are also interesting because they raise questions about the role of audiation training that is usually present in most formal music training, including the numerous external examining bodies for instrumental music. The findings of this study contribute to the literature by providing some support for the numerous claims of problems in audiation training within formal education.
Audiation Training Concerns

A common theme running throughout the literature reviewed previously in this thesis was that audiation is amenable to appropriate training. This assumption is evident in formal music education where some kind of audiation training exists in most courses. All of the tertiary institutions approached to participate in this study featured to a varying extent, some component of audiation training in their curricula. In addition, 80% of participants were trained in music programs at secondary schools, which usually incorporate some form of audiation training, as do the external instrumental examinations at higher levels. It is therefore one of the most interesting findings of the study that there was no significant evidence that any audiation training had enhanced melodic pattern audiation or TU.

There is wide consensus that well trained musicians should be able to discern the pitches of a passage of tonal music. Karpinski (2000: 39) for example, describes this ability as a basic skill that is essential for any substantial work in the tonal system. At face value these tertiary trained musicians should have been able to tonally understand the relatively simple melody of the MTT and to notate it. (This is without discussing the challenge of more complex music at rapid tempos containing chromaticism, large leaps or non-diatonic tones). Yet most trained musicians were unable to accomplish this.

The findings of this study provide some empirical evidence to support the numerous claims cited earlier, that audiation training within formal music education may not be optimal (Bridges, 1984; Odam, 1995; Pratt, 1998; P. Priest, 1989; Stowasser, 1997). The question that arises from the results of this study is whether there may be something in the way audiation training is being approached that does not seem to develop the ability to audiate and understand tonal music easily and quickly.

Lack of Consensus on Audiation Training

Butler and Lochstampfor (1993) identified a widespread lack of consensus on the rationale for audiation training. They found that audiation training goals and methods were often discussed at a superficial level without addressing the underlying reasoning behind what the various approaches were meant to do, or whether they were effective. They observed a pressing need for a careful and systematic study of the goals and methods of audiation training. This lack of consensus was also reflected in results of surveys by Pratt (1998) and Jeanneret et al. (2003).

Atomistic Audiation Training

One area of audiation training that is the focus of particularly strong criticism by a number of researchers is atomistic audiation training: “drill, practice, and testing of the identification and performance of small, acontextual musical elements” (Karpinski 2000b). This includes identifying and performing isolated intervals and chords and their inversions.
There is a long tradition of treating intervals as the cornerstone of audiation training (Klonoski, 2000) and this approach to developing audiation continues as a widespread practice in formal education. This was confirmed in discussions with lecturers at the institutions approached for this study. Most audiation training programs were based around learning to recognize atomistic musical elements. At secondary level, several widely used audiation training texts for year 12 are also based on recognizing atomistic elements.

Despite its widespread practice, the atomistic approach to audiation training is criticized strongly. Karpinski (2000:53) compares it to “training literature majors to list all of the phonemes or the number of letters in each word of a Shakespeare play”. He cites “overwhelming experimental and clinical evidence” of almost no connection between identifying isolated intervals and identifying them in a tonal context (Karpinski, 2000b). This is because in the tonal system, the scale degrees of melody notes have a tonal function (Dowling 2000). The function of intervals changes, and so does their effect depending on their tonal context (Karpinski, 2000:55). This, Karpinski argues, points away from the study of intervals out of context, and towards the need to study individual scale degree function (see also Klonoski, 2000).

The results of this present study, in which many trained musicians failed to recognize the most fundamental intervals of the Western scale, may provide some support that atomistic aural training has not equipped these musicians with the ability to recognize intervals in a tonal context.

Linked to the criticisms of atomistic approach, are criticisms of the widespread use in audiation training of artificially constructed music, something that is contrary to the aim of helping students to hear and perform real music (Karpinski 2000b). The criticisms of atomistic audiation training extend into the area of computer assisted instruction such as software programs designed to improve audiation. Many of these programs involve activities based around atomistic elements of music. Discussing the advent of software for audiation training Karpinski (2000b) for example suggests it has been largely “a revolution in the medium but not the message”. He describes “same old tired pseudo-pedagogy…using flashy new technology…[to]…simply reinforce poor concepts and faulty learning strategies in more seductive ways”.

The criticisms of the widespread practice in formal education of atomistic audiation training are interesting for this discussion, because they offer a potential source of the poor TU found in this present study. The results of this study provide some empirical support for these concerns about the limitations of the atomistic approach to audiation development. The MTT melody contained only simple diatonic intervals. The participants in the study are certain to have encountered these intervals in audiation training classes. Yet, the results showed that years of audiation training through secondary and then tertiary education had not prepared musicians to recognize, in context, the most fundamentally basic of diatonic intervals. The results of this study have contributed to the
literature by providing some support for the idea that audiation training in many formal settings may not always be effective.

**Limitations of the Study**

The scientific reliability and validity of this research rest on several issues. First, the study comes from a sample survey. This raises all of the issues of reliability in surveys. The most notable of these is response rate. The response rate at the institutional level was 64% (14 out of 22 institutions agreed to participate). At the individual level, the response rate was 52.5%. Low response rates can compromise validity because those who choose to respond may be different from those who decline to respond, or are not available to be measured.

At the institutional level, there was a mixture of reasons for institutions declining to participate. One reason given was a concern that students might resent the intrusion to their normal course of study, and perhaps even register a hostile reaction to the research requirement. It is very difficult to say whether this institutional reaction might be associated with students’ audiation abilities. It is worth noting that there was very little evidence of such a reaction from the students at participating institutions; in fact, the prima facie reaction was of engagement, and positive awareness of the issues being canvassed in the research.

The response rate at the individual level is reasonable for a survey of this kind. Reasons for lack of participation included absence on the day (due to illness or other), alternative demands on participants’ time, and refusal to participate. One important phenomenon that reduced the response rate was when a particular musical educator, at an institution that had agreed to participate, acted as a “gate-keeper” and prevented a whole class from participating. Again, the possibilities for response bias from these various causes of non-response are hard to identify.

On the other hand, two strengths of the study are its scope and its sample size. Students were sampled from every state and territory in Australia, and the eventual sample size was 340. Thus it was a substantial, national study of tertiary music students. This allowed statistical modelling of the data in order to obtain meaningful insights into the associations between variables and the predictive power of explanatory variables.

A second important potential limitation is measurement: in particular, the measurement of audiation. The difficulty of finding a task, or set of tasks, that adequately captures this subtle and somewhat elusive concept, has been described elsewhere in the thesis (Chapter 4). The two main outcomes eventually used were chosen after extensive considerations of a number of alternatives. The thesis has argued why these two measures (the Musical Transcription Task and the Musical Ear Test) do, in combination, offer important insights into audiation ability. However, better measures would be very useful, and would make a valuable contribution to ongoing research.
CHAPTER 8: DISCUSSION AND CONCLUSIONS

Further Research

Suggestions for further research have been mentioned in various parts of this thesis. The most prominent of these, as mentioned in the previous section, is a need for research into instruments to measure audiation in musicians. As discussed earlier, measurement of any kind of musical skill poses challenges. But “good ears” do exist, and the ability to measure this would add considerably to the effectiveness of instrumental music education. The issue of comprehension in music is complex and not well understood. However, the close parallels between music and language could be a potential source of research into this issue. A test for music understanding might mimic in some way the tests of comprehension that must be common throughout language education.

This thesis identified numerous problems in current approaches to instrumental music education. There is a need for research that considers ways of comparing different approaches to musical education, in formal designed studies; ideally randomized controlled trials. It is true that in education generally, randomized trials are difficult to achieve, but they have been used and it is worthwhile aspiring to the gold standard for evaluating alternative interventions. If such designs are not used, at the very least, research into alternative methods could be undertaken that was systematic and according to a developed protocol, rather than relying on purely observational data.

An important need suggested by the findings of this study, is for music researchers to begin to recognize and acknowledge that although it is ubiquitous, music recitation is only one very specific form of musical training. It is a historically recent phenomenon, and is unusual in global terms. And as this study has attempted to show, recitation can be effected without the development of genuine musical representations: audiation.

Much music cognition research, and many studies seeking to compare “musicians” with “non-musicians” have used reciting musicians. This suggests there is an important need for studies that examine other forms of music performance expertise that are not based around learning and performing from notation. This kind of research might potentially benefit by first assessing the audiation skills of participants, to examine whether a person’s musical training has led to genuine musical representations, or other, non-aural ones. (Hence the need for a test of audiation as mentioned above).

Questions Raised for Music Education

The preceding section of the discussion highlighted the fundamental importance of audiation in traditional music performance expertise. The present study did not directly address the merits and effectiveness of alternative approaches to musical education. Rather, the audiation performance of music students who have largely come through the recent Western approach was studied. The results do not indicate that this approach produces a high level of proficiency in audiation and
genuine musical understanding. This supports criticisms of current practices in audiation training as being often ineffective. One of the main criticisms is of the atomistic approach.

It is therefore relevant to offer some speculation on alternatives that have been proposed. This study cannot conclude that these approaches would give better outcomes than current formal education, but it does raise the question of what else should be considered, and whether available and existing alternatives might give superior outcomes. The following discussion addresses this speculation.

In contrast to atomistic approaches, many authors have urged a return to traditional holistic approaches to developing audiation. A holistic approach involves the use of authentic musical passages, rather than isolated, acontextual intervals or chords. This has some important parallels with the listening-copying activities normally associated with the traditional conception of music performance expertise.

As discussed at the beginning of this thesis, although music is not a language, the similarities between the two things are very great and the traditional process of learning them is very similar. (Gordon, 2007; Gruhn, 2006; Patel, 2008; Mithen, 2006). For most of human history and still in many parts of the world, music performance expertise has been acquired through an aural culture: listening, copying, and imitating. Descriptions of this kind of expertise often use analogies with language expertise. Prior to the 20th Century this was also the case for learning Western classical music:

Short musical patterns and motifs were practiced in a similar way that children learn words or nonsense syllables by babbling. The performance of eight-bar phrases corresponded to the speaking of sentences. The invention of studies enabled students to practice patterns of accentuation and to create new “words” in the music language. (Gellrich & Sundin, 1993:137).

Numerous authors emphasize the advantages of the listening-copying approach for audiation training. A recent study by Baker and Green (2013) found that a listening-copying approach was effective in developing audiation in teenagers. One of the important characteristics of listening-copying is that it is based around listening to real music, as compared with musical exercises contrived for the purpose of training. Priest, found it to be

the best and most useful form of aural activity I have experienced, both as a player and as a teacher. It achieves what we try and so often fail to do in sight singing and aural dictation, and it brings immediate satisfaction to the player who wants to play that tune. (1985:20)
The advantages for enjoyment and motivation have been remarked on by several authors. Toplis (1990) believed listening-copying merited a special place in the music curriculum not only for its audiation training benefits but for its motivational factor. Listening-copying is also thought to contribute not only to effective audiation training, but also to ongoing engagement with music after formal training (Green, 2002; Regelski, 1975; Woody & Lehmann, 2010).

**Spontaneous Musical Expression**

For many authors, the best way to develop audiation is through a return to traditional conceptions of music performance expertise. Many authors urge the re-integration of spontaneous musical expression into all levels of music training, from the very beginning of lessons (Peggie 1985; Sawyer, 2007; Dobbins, 1980; Gruhn, 2006; Gordon, 2007; Green, 2002). Analogies with language are often used to emphasize the effectiveness of this approach to audiation development:

> Improvisation, like verbal language skills, should be introduced in the earliest stages of education to become a natural and fully functioning part of a person’s creative skills. It should be taught through an approach that integrates ear training, sight reading instrumental and vocal technique, and theory into a unified and complete understanding of music as language. (Dobbins, 1980:41)

Not only is this seen as promoting creativity and self expression, but also as a way of enhancing recitation skills. Musicians who are audiating will recite written music better, and will be better ensemble performers (Sawyer, 2007; Dobbins, 1980; Gordon, 2007).

**Appropriate Learning Sequence**

Numerous authors emphasize the need to reconsider the current sequence of instrumental music learning. They suggest that audiation training should become the foremost priority when learning an instrument. This is particularly so in regard to developing authentic music literacy. Gordon (2007:148) for example suggested “the ear must be taught before the eye if the eye is to take meaning from the printed page of notation”. Some authors see the current emphasis in formal music education on developing motor and reading skills as leading to only a short-term gain. The development of audiation takes longer but leads ultimately to authentic musical expressive skills (Gruhn, 1997; 2006). Analogies with language are often used to suggest the need for an appropriate sequence of music learning. It is necessary “to take that time for the learning of music in a similar way as one has learned the mother tongue which is never learned in a short period of time” (Gruhn, 1997:45).

As Gordon (2007:297) says, “Students learn two instruments, their audiation instrument and the actual music instrument. To make satisfactory progress in instrumental music, they first learn their audiation instrument as readiness for learning to play an actual music instrument.”
CHAPTER 8: DISCUSSION AND CONCLUSIONS

For many authors, audiation training should be a part of every aspect of music activity and at every level. Learning should always be focused on music as a sound system.

Summary

The purpose of this study was to investigate whether claims in the literature about audiation in trained musicians were supported by empirical evidence and what background factors may be associated with these abilities.

This purpose was achieved in a survey of audiation in Australian tertiary music students that was carried out in 2012-13. Responses were obtained from 340 students. Two tests of audiation were selected. A musical transcription task was used to measure TU: the ability to hear a passage of tonal music and infer a tonal centre, discern melodic contour and assign scale degrees. A melodic pairs test was used to measure melodic pattern audiation. Melodic pattern audiation was defined as the ability to discriminate between pairs of short melodic patterns. Background information on participants’ music learning and pre-existing characteristics was gathered using a researcher designed questionnaire. Statistical analyses were carried out on the data gathered from the sample. Results from the study can be summarized according to the nine research questions.

Question 1: What structural elements of melodic patterns are associated with audiation difficulty?

Several structural elements contributed to a hierarchy of audiation difficulty among the MET melodic patterns. Atonality was the most challenging factor, especially if this included a pitch change. Patterns with a contour change were easiest. Length of pattern was associated with difficulty level suggesting the effect of storage limitations of musical working memory. Test item order did not affect performance, suggesting fatigue was not a factor.

Question 2: What degree of association exists between melodic pattern audiation and musical training?

There was almost no association between melodic pattern audiation and type or extent of musical training. The sole training variable remaining after predictive modelling was whether a person had completed a high level instrumental examination, but this was marginally significant.

Question 3: What degree of association exists between melodic pattern audiation and pre-existing traits?

Pre-existing traits of perfect pitch and gender were the two other variables remaining after predictive modelling. Males, and those with perfect pitch had a small advantage in melodic pattern audiation but the association was marginally significant.
Question 4: To what degree can melodic pattern audiation be predicted from training and pre-existing variables.

The three variables remaining in the model, exam at grade 6, gender and perfect pitch, accounted for only a small amount of the total variation in the MET. The regression model had an $R^2$ value of 3.80%, which indicates that there is a large amount of variation in the MET scores that is not explained by the model. From the measures of training and pre-existing variables used in this study, melodic pattern audiation as measured by the MET can be predicted to only a small degree.

Question 5: To what degree do trained musicians understand heard tonal music?

The test for tonal understanding (MTT) showed that three quarters of trained musicians did not understand a simple tonal melody after six hearings. Two thirds of trained musicians were unable to correctly identify even the contour of the melody. Many musicians lacked TU of simple intervals. Many musicians were unable to infer a tonal centre in the heard melody. The simplicity of the task, as estimated by established difficulty criteria and comparisons with similar tasks, suggests that the degree to which trained musicians understand tonal music is relatively limited.

Question 6: What degree of association exists between TU and melodic pattern audiation?

Performance on the notation task (MTT) was analyzed in relation to performance on the non-notation task (MET). This analysis revealed that the degree of association between TU and melodic pattern audiation was significant ($r = 0.37, P < 0.001$). Participants who performed poorly on the notation based task (MTT) also performed poorly on the non-notation task (MET). This finding suggests that the low rates of TU of musicians is not necessarily attributable to difficulties with notation. Rather, this points towards difficulties in audiation and specifically TU.

Question 7: What degree of association exists between TU and musical training?

No evidence was found that the extent of a musician’s training, including years of secondary and tertiary training, examination level and years playing an instrument was associated with TU. Teaching method and type of instrument were also not associated with TU. The two training variables remaining after regression modelling were type of music played, and way of learning.

Type of music played was strongly associated with TU. The odds of TU for classical musicians were estimated to be almost twice as high as for the combination musicians. The advantage for classical musicians increased to almost ten times as high when compared to the popular musicians. By far those least likely to have TU were the popular musicians no matter how they learned.

Less strongly associated was way of learning. Those who learned from a mixture of ear and notation had better TU than those mainly learning from notation. Both of these groups had much better TU than the ear learners.
CHAPTER 8: DISCUSSION AND CONCLUSIONS

**Question 8: What degree of association exists between TU and pre-existing traits?**

Pre-existing traits were most strongly associated with TU. These were gender, language and perfect pitch. Possession of perfect pitch was most strongly associated. The odds of TU were 13 times greater for those with perfect pitch than for ordinary musicians.

Asian native language was also strongly associated with TU even after adjusting for all other variables including perfect pitch. For native Asian language speakers the odd of TU were estimated to be almost five times higher than for the non Asian speakers.

Gender is less strongly associated with TU. The predicted percentages of TU among males were consistently higher than for females with the odds of TU for males estimated to be twice as high as for females.

**Question 9: To what degree can TU be predicted from training and pre-existing variables?**

The strongest predictors of TU, as indicated by both the size of the odds ratios and the levels of statistical significance, were perfect pitch and type of music played, followed to a lesser extent by type of language. Way of learning and gender were also significant predictors, but less strongly. On the evidence from this survey, TU can be predicted strongly by perfect pitch, type of music played and language group, and less convincingly by gender and main way of learning.

**Conclusion**

This thesis began by outlining the close interrelationship between music and language. An integral part of all human cultures, both are forms of human communication involving recognizing, thinking, and creating sounds. These close parallels are reflected to this day in most world music cultures where listening and copying, and spontaneous expression of sounds, are integrated throughout instrumental music performance. Evidence suggests that for humans, music is as natural as language. Numerous claims suggested, however, that for many formally trained musicians, this may not be the case.

These claims suggested that rather than thinking in sound, many formally trained musicians were reliant on non-audiation representations to generate music performance. This was thought to leave musicians without the traditional musical capacity for spontaneous expression and creativity. Other research suggested that some traditional listening-copying approaches to acquiring music skills may lead to more effective audiation skills.

In order to investigate these claims, and to identify factors associated with audiation, this study firstly identified a gap in the knowledge about these issues. This was important because the issue has been described as in some ways hidden, as instrumental music performance can be generated from distinctly different mental representations.
CHAPTER 8: DISCUSSION AND CONCLUSIONS

This thesis also identified a widespread assumption in the literature of recitation as a synonym for music performance expertise. Traditional music expertise based on listening and copying and spontaneous musical expression was relatively neglected. By identifying the conflation of these issues, this thesis clarified the importance of audiation and the need for empirical evidence about these issues.

Empirical evidence gathered by this study showed that many formally trained musicians had a limited ability to understand a heard simple melody. This contributes to the literature by providing evidence to support many of the claims that were previously largely anecdotal, and to provide evidence for a situation that is hidden. To paraphrase Gordon (2001:1) it would probably surprise many people to discover that many tertiary musicians do not have the ability to understand heard tonal music without first seeing it in notation.

The findings of this study contribute to the literature on music literacy and in particular the widespread assumption that playing an instrument by using notation is evidence of music literacy. The evidence of limited TU in most trained musicians contributes some support to the many authors who strongly question this assumption (Gordon, 2007; Bridges, 1984; Campbell 1989; Field 1979; Waller, 2010; Bartel, 2006). The findings support claims that many musicians are likely to be decoding rather than truly reading, and using other non-audiation representations to generate performance.

The findings of this study provide a contribution to the literature concerning claims that current formal music education may not be conducive to audiation development (Bridges, 1984; Gordon, 2007; Jeanneret et al., 2003; Karpinski, 2000; Leong, 1999; Odam, 1995; P. Priest, 1989).

The first of these findings was that musical training was not strongly associated with either melodic pattern audiation or TU. The second finding was that pre-existing traits were most strongly associated with audiation in trained musicians. This is potentially of interest to educators and curriculum designers as these findings may suggest that the goals of music education, particularly as outlined in the Australian curriculum are not being achieved.

A third finding, that popular musicians showed no advantage in audiation and had limited TU adds empirical evidence to what have otherwise been mainly anecdotal claims that these musicians should have superior audiation. This unexpected finding may have potentially important implications for music educators, because it may suggest some support for the claims that once popular styles of music are absorbed into the formal system, audiation development is limited (Green, 2002; Woody & Lehmann, 2010).

An important implication of these findings is that they provide some confirmation of numerous claims that without adequately developed audiation, many musicians lack the ability to express themselves as spontaneously and as freely as in language.
The following quote from more than a century ago encapsulates in a few words, what this entire thesis has attempted to say in thousands:

There is really no such thing as taking piano lessons. The piano is simply the instrument we choose for the expression of musical ideas. Music itself is in the mind, and therefore the teaching of it should be distinctly a mental training. (Seymour, 1910: preface)
REFERENCES


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References


REFERENCES


### Appendixes

#### Appendix 1: Selected Published Aural Tests

<table>
<thead>
<tr>
<th>Test Name</th>
<th>Aptitude or Achievement</th>
<th>Duration</th>
<th>Sections</th>
<th>Target group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australian Test For Advanced Music Studies</td>
<td>Achievement</td>
<td>3hrs</td>
<td>Aural imagery; reading; comprehension</td>
<td>16-Adult</td>
</tr>
<tr>
<td>Bentley Measures of Musical Abilities (1966)</td>
<td>Aptitude</td>
<td>20mins</td>
<td>Pitch; Tonal memory; Rhythmic memory; Chord analysis</td>
<td>8-14</td>
</tr>
<tr>
<td>Colwell Music Achievement Tests (1970)</td>
<td>Achievement</td>
<td>2 hrs</td>
<td>Pitch; Interval; Metre; maj/min; tonal centre; notation; inst recognition; style; chords;</td>
<td>7-18</td>
</tr>
<tr>
<td>Drake musical aptitude tests</td>
<td>Aptitude</td>
<td>60mins</td>
<td>Intervals; Retentivity; Intuition; Memory</td>
<td>8-Adult</td>
</tr>
<tr>
<td>Farnum Music Test</td>
<td>Achievement</td>
<td>45 mins</td>
<td>Notation; Cadence; Patterns; Symbol</td>
<td>8-15</td>
</tr>
<tr>
<td>Gaston test of musicality</td>
<td>Aptitude</td>
<td>40 mins</td>
<td>Chord; Melody recognition</td>
<td>10-18</td>
</tr>
<tr>
<td>Gordon Advanced Measures of Music Audiation</td>
<td>Aptitude</td>
<td>15 mins</td>
<td>Melody; Rhythm</td>
<td>12-adult</td>
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<tr>
<td>Gordon primary measures of music audiation</td>
<td>Aptitude</td>
<td>40 mins</td>
<td>Tonal; Rhythmic</td>
<td>5-8</td>
</tr>
<tr>
<td>Musical Aptitude Profile (1965)</td>
<td>Aptitude</td>
<td>3 days</td>
<td>Tonal imagery; Rhythm imagery; Musical sensitivity;</td>
<td>9-Adult</td>
</tr>
<tr>
<td>Iowa Tests of Musical Literacy</td>
<td>Achievement</td>
<td>60 mins</td>
<td>Maj/min recognition; Reading; Metre; Notation</td>
<td>8-18</td>
</tr>
<tr>
<td>Kwalwasser-Dykema Battery</td>
<td>Aptitude</td>
<td>60 mins</td>
<td>Pitch; Quality; Intensity; Tonal; Rhythm; Melodic taste; Imagery</td>
<td>10-Adult</td>
</tr>
<tr>
<td>Mainwaring tests of musical ability (1931)</td>
<td>Achievement</td>
<td>60 mins</td>
<td>Pitch; Rhythm; Recall</td>
<td>8-18</td>
</tr>
<tr>
<td>Montreal Battery of Evaluation of Amusia (Peretz, et al.2003).</td>
<td>Aptitude</td>
<td>90 mins</td>
<td>Scales; intervals; rhythm; metre</td>
<td>Amusia</td>
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<td>Musical Ear Test (2010)</td>
<td>Achievement</td>
<td>20 mins</td>
<td>Melody; Rhythm</td>
<td>open</td>
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<tr>
<td>Seashore measures of musical talents (1919)</td>
<td>Aptitude</td>
<td>60 mins</td>
<td>Pitch; Intensity; Consonance; Tonal Memory; Time;</td>
<td>10-Adult</td>
</tr>
<tr>
<td>Wing standardised tests of mus. Intelligence</td>
<td>Aptitude</td>
<td>60 mins</td>
<td>Chord analysis; Pitch change; Memory; Rhythm; Harmony; Intensity; Phrasing</td>
<td>8-Adult</td>
</tr>
<tr>
<td>Zenatti music tests for young children</td>
<td>Aptitude</td>
<td>Open</td>
<td>Rhythm; Melody; Harmony; Aesthetic judgement</td>
<td>4-8</td>
</tr>
</tbody>
</table>

Adapted From Shuter-Dyson & Gabriel (1981).
Appendix 2: Ethics Approval Letter

10 October 2011

Dr Neryl Jeanneret
Melbourne Graduate School of Education
The University of Melbourne

Dear Dr Jeanneret,

I am pleased to advise that the Melbourne Graduate School of Education Human Ethics Advisory Group (MGSE HEAG) has approved the following Minimal Risk application:

- **Project title:** Aural skills in tertiary settings and beyond.
- **Researchers:** Neryl Jeanneret, Christopher Sommervelle and Ian Gordan
- **Ethics ID:** 1035233
- **MGSE HEAG ID:** 179/11

The project has been approved for the period **10 October 2011 to 31 December 2011**.

It is your responsibility to ensure that all people associated with the Project are made aware of what has actually been approved.

Research projects are normally approved to 31 December of the year of approval. Projects may be renewed yearly for up to a total of five years upon receipt of a satisfactory annual report. If a project is to continue beyond five years a new application will normally need to be submitted.

Please note that the following conditions apply to your approval. Failure to abide by these conditions may result in suspension or discontinuation of approval and/or disciplinary action.

1. **Limit of Approval:** Approval is limited strictly to the research as submitted in your Project application.
2. **Amendments to Project:** Any subsequent variations or modifications you might wish to make to the Project must be notified formally to the Human Ethics Advisory Group for further consideration and approval before the revised Project can commence. If the Human Ethics Advisory Group considers that the proposed amendments are significant, you may be required to submit a new application for approval of the revised Project.
3. **Incidents or adverse affects:** Researchers must report immediately to the Advisory Group and the relevant Sub-Committee anything which might affect the ethical acceptability of the protocol including adverse effects on participants or unforeseen events that might affect continued ethical acceptability of the Project. Failure to do so may result in suspension or cancellation of approval.
4. **Monitoring:** All projects are subject to monitoring at any time by the Human Research Ethics Committee.
5. **Annual Report:** Please be aware that the Human Research Ethics Committee requires that researchers submit an annual report on each of their projects at the end of the year, or at the conclusion of a project if it continues for less than this time. Failure to submit an annual report will mean that ethics approval will lapse.
6. **Auditing:** All projects may be subject to audit by members of the Sub-Committee.

Please quote the ethics registration number and the name of the Project in any future correspondence.

On behalf of the Ethics Committee I wish you well in your research.

Yours sincerely,

Associate Professor Leo Gordegebuere
Chairperson, Melbourne Graduate School of Education Human Ethics Advisory Group
Phone: 83440619, Email: leo.g@unimelb.edu.au

cc: Christopher Sommervelle, Ian Gordan and Human Research Ethics Committee, Melbourne Research Office.

---

Melbourne Education Research Institute (MERI)
Melbourne Graduate School of Education | The University of Melbourne
Level 5 | 100 Leicester Street | Carlton Victoria 3053 | Australia
Appendix 3: Plain Language Statements

PLAIN LANGUAGE STATEMENT – Head of Music

Project: “Aural Skills in Tertiary Settings and Beyond”
Principle Supervisor: Dr Neryl Jeanneret
Co-supervisor: Professor Ian Gordon
Student Researcher: Chris Sommerville

Introduction
As a leading music education institution in Australia, your music department is being invited to take part in a PhD research study. The main aim of the study is to evaluate the aural skills and learning background of tertiary music students around Australia. It is hoped the findings may contribute to a better understanding of how tertiary music students develop their aural skills. This project has been approved by the Human Research Ethics Committee.

What will the music department be asked to do?
Should you agree to participate, the responsible lecturer will be asked to contribute in three ways:
• permit their music students to undertake a short aural test and questionnaire.
• organize a convenient time in which we would come to the class to administer the test and questionnaire. Students will be asked to fill in a short questionnaire giving information about their music learning background. They will then be asked to listen to several pairs of melodies and tick a box to indicate whether they are the “same” or “different”. They will also be asked transcribe a short melody. We estimate that the total time commitment for this would be approximately 30 minutes.
• participate in a short interview of about 15 minutes to give their views on aural training

Why participate?
The survey is envisaged as a diagnostic tool for aural skill. By using code names, feedback from the test will be available to students and lecturers. It is not intended as a competitive assessment between students or institutions. It is therefore hoped that a majority of students can be encouraged to undertake the test regardless of their perceived aural skill abilities. (In pilot testing, for example, we have found some interesting anomalies). This will help us build up an accurate picture through as wide a survey as possible. The survey is aimed at furthering our understanding of aural skill development. Therefore the views on aural training gained from the interview would also be important.

How will confidentiality be protected?
We intend to protect anonymity and the confidentiality of the student and interview responses to the fullest possible extent, within the limits of the law. A code-name will be used for the responses on the aural tests and questionnaire so that students will not be identified. Interview data, including institution, will be completely anonymous. The data will be kept securely in the Melbourne Graduate School of Education for five years from the date of publication, before being destroyed.
How will I receive feedback?
A dissemination of the findings will be available on request from the Melbourne Graduate School of Education.

Will participation prejudice me in any way?
Your participation in this study is completely voluntary. Should you wish to withdraw at any stage, or to withdraw any unprocessed data you have supplied, you are free to do so without prejudice.

Where can I get further information?
Should you require any further information, or have any concerns, please do not hesitate to contact any of the researchers on the numbers given below. Should you have any concerns about the conduct of the project, you are welcome to contact the Executive Officer, Human Research Ethics, The University of Melbourne, on ph: 8344 2073, or fax: 9347 6739.

How do I agree to participate?
If you would like to participate, please indicate that you have read and understood this information by signing the accompanying consent form and returning it in the envelope provided. The researchers will then arrange with you how best they should contact the appropriate lecturer for permission to proceed with the tests.

<table>
<thead>
<tr>
<th>Dr. Neryl Jeanneret (Supervisor)</th>
<th>Professor Ian Gordon (Co-supervisor)</th>
<th>Mr Chris Sommerville (Research student)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ph. (03) 8344 8882</td>
<td>(03) 8344 6995</td>
<td>0409 966 892</td>
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<tr>
<td>email: <a href="mailto:neryij@unimelb.edu.au">neryij@unimelb.edu.au</a></td>
<td><a href="mailto:irg@unimelb.edu.au">irg@unimelb.edu.au</a></td>
<td><a href="mailto:chrisls@student.unimelb.edu.au">chrisls@student.unimelb.edu.au</a></td>
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PLAIN LANGUAGE STATEMENT – LECTURER

Project: “Aural Skills in Tertiary Settings and Beyond”
Principle Supervisor: Dr Neryl Jeanneret
Co-supervisor: Professor Ian Gordon
Student Researcher: Chris Sommervelle

Introduction
As a leading music education institution in Australia, your music department is being invited to take part in a PhD research study. The main aim of the study is to evaluate the aural skills and learning background of tertiary music students around Australia. It is hoped the findings may contribute to a better understanding of how tertiary music students develop their aural skills. This project has been approved by the Human Research Ethics Committee.

What will the music department be asked to do?
Should you agree to participate, you will be asked to contribute in three ways:

- permit your music students to undertake a short aural test and questionnaire.
- organize a convenient time in which we would come to the class to administer the test and questionnaire. Students will be asked to fill in a short questionnaire giving information about their music learning background. They will then be asked to listen to several pairs of melodies and tick a box to indicate whether they are the “same” or “different”. They will also be asked transcribe a short melody. We estimate that the total time commitment for this would be approximately 30 minutes.
- participate in a short interview of about 15 minutes to give your views on aural training

Why participate?
The survey is envisaged as a diagnostic tool for aural skill. By using code names, feedback from the test will be available to students and lecturers. It is not intended as a competitive assessment between students or institutions. It is therefore hoped that a majority of students can be encouraged to undertake the test regardless of their perceived aural skill abilities. (In pilot testing, for example, we have found some interesting anomalies). This will help us build up an accurate picture through as wide a survey as possible. The survey is aimed at furthering our understanding of aural skill development. Therefore your views on aural training would also be important.

How will confidentiality be protected?
We intend to protect anonymity and the confidentiality of the student and interview responses to the fullest possible extent, within the limits of the law. A code-name will be used for the responses on the aural tests and questionnaire so that students will not be identified. Interview data, including institution, will be completely anonymous. The data will be kept securely in the Melbourne Graduate School of Education for five years from the date of publication, before being destroyed.
How will I receive feedback?
A dissemination of the findings will be available on request from the Melbourne Graduate School of Education.

Will participation prejudice me in any way?
Your participation in this study is completely voluntary. Should you wish to withdraw at any stage, or to withdraw any unprocessed data you have supplied, you are free to do so without prejudice.

Where can I get further information?
Should you require any further information, or have any concerns, please do not hesitate to contact any of the researchers on the numbers given below. Should you have any concerns about the conduct of the project, you are welcome to contact the Executive Officer, Human Research Ethics, The University of Melbourne, on ph: 8344 2073, or fax: 9347 6739.

How do I agree to participate?
If you would like to participate, please indicate that you have read and understood this information by signing the accompanying consent form and returning it in the envelope provided. The researchers will then arrange with you how best they should contact the appropriate lecturer for permission to proceed with the tests.

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<td><a href="mailto:chrisls@student.unimelb.edu.au">chrisls@student.unimelb.edu.au</a></td>
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REFERENCES

PLAIN LANGUAGE STATEMENT – Student

Project: “Aural Skills in Tertiary Settings and Beyond”
Principle Supervisor: Dr Neryl Jeanneret
Co-Supervisor: Professor Ian Gordon
Student Researcher: Chris Sommerville

Introduction
As a leading music education institution in Australia, your music department is being invited to take part in a PhD research study. The main aim of the study is to evaluate the aural skills and learning background of tertiary music students around Australia. It is hoped the findings may contribute to a better understanding of how tertiary music students develop their aural skills. This project has been approved by the Human Research Ethics Committee.

What will the music department be asked to do?
Should you agree to participate, we would like you, as part of your class group, to take a musical aural test. This would involve listening to several pairs of melodies and answering whether they are the “same” or “different”. You will also be asked to transcribe a short melody, and fill in a short questionnaire giving information about your music learning background. We estimate that the total time commitment for this would be about 30 minutes.

Why participate?
The survey is envisaged as a diagnostic tool for aural skill. By using code names, feedback from the test will be available to you. It is not intended as a competitive assessment between students or institutions. Results will be kept confidential. It is therefore hoped that a majority of students can be encouraged to undertake the test regardless of their perceived aural skill abilities. (In pilot testing, for example, we have found some interesting anomalies). This will help us build up an accurate picture through as wide a survey as possible and further our understanding of aural skill development.

How will confidentiality be protected?
We intend to protect anonymity and the confidentiality of the student responses to the fullest possible extent, within the limits of the law. A code-name will be used for your responses on the aural tests and questionnaire so that you will not be identified. The results will be entirely confidential and will not affect your studies or assessment. The data will be kept securely in the Melbourne Graduate School of Education for five years from the date of publication, before being destroyed.

How will I receive feedback?
A dissemination of the findings will be available on request from the Melbourne Graduate School of Education.

Will participation prejudice me in any way?
Your participation in this study is completely voluntary. Should you wish to withdraw at any stage, or to withdraw any unprocessed data you have supplied, you are free to do so without prejudice. Again, the results will be entirely confidential and will not affect your studies or assessment.

Where can I get further information?
Should you require any further information, or have any concerns, please do not hesitate to contact any of the researchers on the numbers given below. Should you have any concerns about the conduct of the project, you are welcome to contact the Executive Officer, Human Research Ethics, The University of Melbourne, on ph: 8344 2073, or fax: 9347 6739.

How do I agree to participate?
If you would like to participate, please indicate that you have read and understood this information by signing the accompanying consent form and returning it to the lecturer. The researchers will then arrange with your lecturer a mutually convenient time to complete the questionnaire and tests.

Dr. Neryl Jeanneret (Supervisor)  Professor Ian Gordon (Co-supervisor)  Mr Chris Sommerville (Research student)
ph. (03) 8344 8882  (03) 8344 6995  0409 966 892
email: neryl@unimelb.edu.au  lrg@unimelb.edu.au  chrisls@student.unimelb.edu.au

Melbourne Graduate School of Education
The University of Melbourne Victoria 3010 Australia
T: +61 3 8344 8285 F: +61 3 8344 8529 W: www.education.unimelb.edu.au
HREC: 1035233 Date: 20/04/12 Version: 2
Appendix 4: Consent Forms

CONSENT FORM: Head of Music

PROJECT TITLE: AURAL SKILLS IN TERTIARY SETTINGS AND BEYOND

Name of participant:

Name of investigator(s): Dr. Neryl Jeanneret, Professor Ian Gordon, Chris Sommerville

1. I consent to participate in the project named above, the particulars of which - including details of aural tests, questionnaires, and interview - have been explained to me. A written copy of the information has been given to me to keep.

2. I authorise the researcher or student researcher to use for this purpose the aural tests, questionnaires and interview.

3. I acknowledge that:

(a) the possible effects of the aural tests, questionnaires and interview have been explained to me to my satisfaction;

(b) I have been informed that I am free to withdraw from the project at any time without explanation or prejudice and to withdraw any unprocessed data previously supplied;

(c) The project is for the purpose of research;

(d) I have been informed that the confidentiality of the information I provide will be safeguarded subject to any legal requirements;

☐ I wish to receive a copy of the dissemination report.

Signature Date

(Participant)

Melbourne Graduate School of Education
The University of Melbourne Victoria 3010 Australia
T: +61 3 8344 8285 F: +61 3 8344 8529 W: www.education.unimelb.edu.au HREC: 1035233 Date: 20/04/12 Version: 2
CONSENT FORM: LECTURER

PROJECT TITLE: AURAL SKILLS IN TERTIARY SETTINGS AND BEYOND

Name of participant:

Name of investigator(s): Dr. Neryl Jeanneret, Professor Ian Gordon, Chris Sommervelle

1. I consent to participate in the project named above, the particulars of which - including details of aural tests, questionnaires, and interview - have been explained to me. A written copy of the information has been given to me to keep.

2. I authorise the researcher or student researcher to use for this purpose the aural tests, questionnaires and interview.

3. I acknowledge that:

   (a) the possible effects of the aural tests, questionnaires and interview have been explained to me to my satisfaction;

   (b) I have been informed that I am free to withdraw from the project at any time without explanation or prejudice and to withdraw any unprocessed data previously supplied;

   (c) The project is for the purpose of research;

   (d) I have been informed that the confidentiality of the information I provide will be safeguarded subject to any legal requirements;

☐ I wish to receive a copy of the dissemination report.

___  __________
Signature  Date

(Participant)

Melbourne Graduate School of Education
The University of Melbourne Victoria 3010 Australia
T: +61 3 8344 8285 F: +61 3 8344 8529 W: www.education.unimelb.edu.au

HREC: 1035233 Date: 20/04/12 Version: 2
CONSENT FORM: STUDENTS

PROJECT TITLE: AURAL SKILLS IN TERTIARY SETTINGS AND BEYOND

Name of participant:

Name of investigator(s): Dr. Neryl Jeanneret, Professor Ian Gordon, Chris Sommervelle

1. I consent to participate in the project named above, the particulars of which - including details of aural tests and questionnaires - have been explained to me. A written copy of the information has been given to me to keep.

2. I authorise the researcher or student researcher to use for this purpose the aural tests and questionnaires.

3. I acknowledge that:
   (a) the possible effects of the aural tests and questionnaires have been explained to me to my satisfaction;
   (b) I have been informed that I am free to withdraw from the project at any time without explanation or prejudice and to withdraw any unprocessed data previously supplied;
   (c) The project is for the purpose of research;
   (d) I have been informed that the confidentiality of the information I provide will be safeguarded subject to any legal requirements;

☐ I wish to receive a copy of the dissemination report.

Signature ____________________________ Date ____________________________

(Participant)

Melbourne Graduate School of Education
The University of Melbourne Victoria 3010 Australia
T: +61 3 8344 8285 F: +61 3 8344 8529 W: www.education.unimelb.edu.au

HREC: 1035233 Date: 20/04/12 Version: 2
**Melodic transcription test**

This exercise requires listening to a short musical excerpt and writing down the vocal melody. Bars 1–10 will be played SIX times for you to notate bars 3–9 of the voice part.

The rhythm is indicated above the stave.

**Playing Times:**
- First playing: 10 second pause
- Second playing: 30 second pause
- Third playing: 1 minute pause
- Fourth playing: 1 minute pause
- Fifth playing: 2 minute pause
- Sixth playing: 2 minute pause

Total time 10 mins.

---

**Voice**

Nächstl. geschürzt die Lippen der

---

**Cello 2**

Blumen, gekreuzt und verschränkt

---

die Schäfte der Fichten,
Comparison of melodic phrases

CodeName of participant: __________________________  Date ....../....../......

**EXAMPLES**

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**THE TEST ITSELF**

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Appendix 7: MBQ Blank

Musical Background Questionnaire

Codename: (e.g. mother’s maiden name, first pet) Date: / / ____________________________

Age: ______________ Gender: Female ☐ Male ☐

What do you consider your native language?: __________________________

Main instrument: ______________ At what age did you begin learning your main instrument? ______

Other instruments: ______________ Do you have perfect pitch? Yes ☐ No ☐

Type of music learning
Since you first began music, what type of music have you mainly learned: (please tick one)
Classical ☐ Popular ☐ A mixture of classical and popular ☐
(rock, jazz, pop, musical theatre, country, blues etc.)
Other ☐
(please specify) ____________________________

Style of music learning:
Since you first began music, what has been your main way of learning: (please tick one)
Learning pieces from notation/sheet music ☐
Learning pieces by ear from recordings ☐
A mixture of both ☐
Other ☐
(please specify) ____________________________

Instrumental/Voice learning
Have you ever had lessons specifically for a music instrument or voice? Yes ☐ No ☐

Which Instrument(s)? ____________________________

Was the teaching based on any particular school of teaching?
Suzuki ☐ Yamaha ☐ Other ☐
Please specify ____________________________

Did you complete formal music exams in your main instrument or voice? Yes ☐ No ☐
If yes, please detail:
Instrument: ____________________________ Examinations system: ____________________________
(e.g. AMEB, Trinity etc) Grade level achieved ____________________________

Secondary music learning
Did you do Year 12 music? Yes ☐ No ☐ If yes which course?
Which options (if applicable) ____________________________
Name of Secondary School: ____________________________

Tertiary music learning
Did you ever do music as a subject at university, TAFE or other post-school institution(s)? Yes ☐ No ☐
If yes, please detail:
Institution/s: ____________________________ Number of Years: ____________________________
Degree/Certificate: Bachelor of Music ☐ Other pls specify ☐

How important do you rate music aural skills as part of becoming an excellent musician?
Highly ☐ Moderately ☐ A little ☐ Not very ☐ Not at all ☐

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