Tough-mindedness and the Enjoyment of Negative Emotions in Music: A Psychophysiological Investigation

Timothy Colin Bednall
67443

Supervised by

Dr David Rawlings and Dr Nick Allen
Declaration

I, Timothy Colin Bednall, declare that the research reported in this thesis was conducted in accordance with principles for the ethical treatment of human subjects as approved for this research by The University of Melbourne Human Research Committee.

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Signed: ________________________ Date: ____/____/_______
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Let me begin by saying that there was nothing easy about this project. Bringing together three divergent area of Psychology, running two pilot studies, performing hours of data entry, learning how to use the physiological measurement technology, recruiting and testing forty participants individually, processing the each physiological variable, analysing copious amounts of data, and writing it all up coherently – was all very hard work! So to the people I am about to thank, know that I am extremely grateful for all the help and support you have given me over this year.

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Dedicated to Robin James Bednall

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Abstract

A fundamental question in musical literature is: how it is possible to enjoy music that expresses negative emotions? Three explanations for this problem have been postulated: 1) listeners experience an inherently pleasant ‘musical’ emotion that is unrelated to music’s emotional content (the aestheticist position), 2) listeners perceive emotions in music but do not experience them (the cognitivist position), 3) listeners experience emotions that match the emotional content of music (the emotivist position). To address this issue, this study examined the relationship between participants’ reported emotional reactions to presentations of emotional music and sounds, and their physiological responses (including facial EMG, startle reflex, heart rate and GSR). Physiological responses were found to vary with the emotional pleasantness and intensity of sounds, but not music, thereby supporting the cognitivist account. In addition, the relationship between Eysenck’s Tough-mindedness or Psychoticism (P) dimension, and reported enjoyment was examined. Compared with tender-minded individuals, high P participants reported significantly greater liking for highly arousing, emotionally unpleasant music, and a marked disliking for emotionally unstimulating music. It is concluded that this result is reflective of the sensation-seeking component of P.
The Enjoyment of Negative Emotions in Music

Tim Bednall

Introduction

It is generally agreed that music has the ability to stimulate listeners’ feelings. However, the relationship between the recognition of emotion within the structure of music and the experience of emotion is not straightforward. An apparent paradox exists, in that music can reflect negative emotions that we would usually be inclined to avoid in everyday life (such as melancholy, anger, fearfulness, etc.), and yet, in many instances we can derive much enjoyment from listening to such pieces (Levinson, 1990).

In addition, numerous studies (e.g. Cattell & Saunders, 1954; Daoussis & McKelvie, 1986; Rawlings & Ciancarelli, 1997; Wheeler, 1985) have suggested strong relationships between relatively enduring personality characteristics and musical preference, as well as the capacity to enjoy certain emotional qualities in music. For example, Cattell and Saunders found that extraversion was associated with the enjoyment of musical pieces characterised by a “joyful but agitated mood”. The personality dimension ‘Tough-mindedness’ has been found to be associated with a liking for “hard rock” music (Rawlings, Hodge, Sherr & Dempsey, 1995; Robinson, Weaver & Zillman, 1996), a style that characteristically tends to express negative emotions and rebellious sentiments.

The present study proposes to address two broad research questions. First, what is the nature of the emotions experienced when listening to music, such that it is possible to enjoy the experience of negative emotions in music? Second, how is Tough-mindedness related to the tendency to enjoy music of negative emotional content? Both questions are addressed in a design that compares the expected and
observed relationships between self-reported emotional responses to presentations of sounds and music, and known physiological correlates of these ratings.

The following sections address the emotional and psychophysiological theoretical frameworks used in this study, the issue of emotional representation in music, and the nature of Tough-mindedness. In the final section of the introduction, specific research hypotheses are outlined relating to the enjoyment of negative emotions in music, and the potential moderating effect of Tough-mindedness on response patterns.

*Theoretical framework of emotions and psychophysiology: the present approach*

Emotions have been conceptualised as states of readiness for adaptive action (Izard, 1993; Lang, 1979), comprising two oppositional systems: an appetitive system that promotes approach-based behaviours, and a defensive system associated with avoidance and protective behaviours (Konorski, 1967; Lang, 1995). According to this view, emotions are associated with efferent activity in verbal-cognitive, motor and physiological systems (Lang, 1993, 1994). Rather than being only secondary reactions to emotional stimulation, such activity is considered to be a constituent feature of emotional states.

A large body of research has demonstrated that differentiated affective states and reliable patterns of associated physiological change can be prompted by symbolic representations of real-life events in a laboratory context, including studies using emotional pictures (e.g. Greenwald, Cook & Lang, 1989; Hare, Wood, Britain & Shadman, 1970; Lang, Greenwald, Bradley & Hamm, 1993; Levenston, Patrick, Bradley & Lang, 2000), film clips (Averill, 1969; Gross & Levenson, 1995;
Tourangeau & Ellsworth, 1979), and auditory stimuli (Bradley & Lang, 2000a; Krumhansl, 1997; Witvliet, 1997). In all of these experiments, self-report and physiological responses have been shown to vary according to the emotional pleasantness and intensity of the presented stimuli.

As with many of the aforementioned investigations, the current study uses a dimensional framework of emotions, which defines emotional responses in terms of two orthogonal scales: valence and arousal. Valence is a pleasantness-unpleasantness dimension associated with appetitive / defensive response dispositions. Arousal refers to the intensity of emotional responses, or the degree of activation. Anger and fear, for example, might be conceptualised as states of low valence (involving defensive preparation for a confrontation or avoidance), and high arousal. This model has been promoted by several theorists (e.g. Mehrabian & Russell, 1974; Watson & Tellegen, 1985), and is consistent with the dimensions uncovered by Osgood, Suci and Tannenbaum’s (1957) influential factor-analytic research into emotional semantics.

A chief benefit of the above framework is that self-reports of valence and arousal have been shown to be associated with reliable patterns of physiological change (for a comprehensive overview, see Bradley & Lang, 2000b). It thereby provides additional (and arguably more objective and direct) indicators of emotional states. In addition, the dimensional framework allows for the possibility that the patterns of physiological change for different emotional states might overlap (e.g. anger and fear), and consequently does not preclude the view that specific emotional meanings can be inferred from the context in which physiological changes are experienced, as was suggested by the renowned experiment of Schachter and Singer (1962).
In laboratory settings, facial electromyographic (EMG) activity in the *zygomaticus major* (zygomatic) and *corrugator supercilii* (corrugator) muscles has been demonstrated to covary with the reported valence of pictorial stimuli (Bradley & Lang, 2000b; Lang et al., 1993). Corrugator muscles are used in the lowering of the brows, and activity in this region has been shown to increase during presentations of emotionally unpleasant stimuli. Zygomatic muscles are those used in smiling, and tend to show greatly increased activity in response to pleasant stimuli, as well as minor activity during unpleasant stimulation due to facial grimacing.

While these measures have been shown to be reliable indicators of emotional states, they are subject to intentional facial manipulation on the part of research participants. An alternate measure of affective valence that overcomes this potential difficulty is the startle reflex, an involuntary eye-blink response triggered by the delivery of a sudden, intense acoustic or visual probe. Lang and his colleagues (Lang, Bradley & Cuthbert, 1990; Vrana, Spence & Lang, 1988) found this response to be inhibited during presentations of pleasant emotional pictures and potentiated during unpleasant presentations. These authors conceptualised the blink as a defensive withdrawal response that was intensified in a synchronous state of defensive readiness or inhibited in a mismatched state of pleasantness, as prompted by the negative/positive emotions experienced during affective presentations. There is also some evidence to suggest that the startle response is modulated by attention. Anthony and Graham (1985) found that potentiation of the reflex occurred when attentional resources were directed to the same sensory modality as the startle probe. For example, if attention were directed to a visual event, a flash probe would produce a larger response than an acoustic probe.
Electrodermal activity (i.e. electrical skin conductance) has shown a tendency to increase with ratings of high emotional arousal, independently of the pleasantness of the experience (Lang et al., 1993; Greenwald et al., 1989). Heart rate also appears to be modulated by the level of emotional intensity, as prior studies using mental imagery tasks have shown that recall of both highly pleasant and unpleasant memories prompts cardiac acceleration (Vrana, Cuthbert & Lang, 1989). However, in studies involving the perception of pictorial stimuli, the presentation of unpleasant scenes caused greater cardiac deceleration than pleasant scenes, suggesting that emotional valence and/or attentional orientation also influence cardiac activity during perception (Lang et al. 1993; Bradley, Cuthbert & Lang, 1990; Greenwald et al., 1989).

In order to evaluate the nature of people’s emotional reactions to auditory stimuli, the current study presented a series of (non-aesthetic) sounds, along with a series of musical excerpts to research participants, while physiological changes (including corrugator/zygomatic EMG activity, startle blink magnitudes, heart rate, and skin conductance) were recorded during these presentations. Participants were asked to rate each presentation on scales of valence, arousal, familiarity and enjoyment. These data were used to address the two major goals of the present study, as outlined in the following sections.

Music and the enjoyment of negative emotions

There has been considerable speculation as to how music possesses the ability to rouse strong emotions in people. Some have suggested (e.g. Goldman, 1992) that emotions arise out of a special appreciation for the artistic quality of a musical piece. Others have focused on how distinctive feelings can be represented by music, and how musical expression might succeed in rousing strong emotions within listeners.
Dowling and Harwood (1986), using the classifications of signs devised by the semiotician Charles Peirce, presented a comprehensive account of three complementary ways which music could represent emotions. They suggested that emotions could be represented through associations with extramusical concepts (an indexical representation), through a formal resemblance to the dynamic and temporal form of emotions (an iconic representation), and through the syntactic structure of musical pieces (a symbolic representation). The latter explanation was compatible with Meyer’s (1956) view of emotional meaning in music – that people create unconscious expectancies (or schemata) about the progression of musical pieces while listening to them, and that violations of these expectancies result in physiological arousal. Drawing on Mandler’s (1984) schema theory, Dowling and Harwood suggested that an unexpected change in the flow of music would result in such arousal and, consequently, a cognitive appraisal about the emotional meaning of that occurrence.

While this account provides a plausible explanation for the various levels of representation of emotion within the form of music, it does not specify whether there exists a relationship between the emotional content of music and the types of emotions actually experienced by musical listeners. Throughout musical and psychological literature, a substantial number of theorists have addressed this issue, whose views could be summarised within three basic standpoints: the aestheticist, cognitivist and emotivist positions.

Aestheticist theorists (Gurney, 1966; Langer, 1942; Bell, 1914) have argued that music rouses a special ‘aesthetic’ emotion that is invariably pleasurable, which listeners may associate with memories of non-musical emotions and important life
episodes. The ‘aesthetic’ emotion was claimed to arise from listeners’ appreciation for the artistic form of musical expressivity, as opposed to the emotional content of music. In opposition, cognitivist theorists (Kivy, 1990; Scruton, 1983) have maintained that emotions are perceived within the structure of music, but not correspondingly experienced. This account does not reject outright the idea that music can stimulate feelings, but purports that any emotions experienced are the result of prior associations, appreciation for the music’s artistry, or psychopathology. Finally, emotivist theorists (Levinson, 1990; Schubert, 1996) have argued that music possesses the ability to stimulate genuine emotions in listeners, which mirror the specific emotions expressed by music.

With regard to the enjoyment of negative emotions in music paradox, both the aestheticist and cognitivist accounts suggest that the expressive content of music does not directly elicit correspondingly negative emotions in people. Levinson (1990) disputed this explanation, and suggested that the appeal of negative emotional content was associated with cathartic benefits for musical listeners, reasoning that feelings evoked by music would occur without direct reference to a real-life context, thereby allowing listeners to savour negative feelings for their own special character. Schubert (1996) proposed a mechanistic explanation for this process, using an associative (neural) network model. He suggested that displeasure centres within this network became inhibited in an aesthetic context, enabling negative emotional stimulation to be experienced pleasurable.

A recent study that attempted to substantiate either the cognitivist or the emotivist account was Krumhansl’s (1997) investigation, which examined music students’ psychophysiological reactions to music of varying emotional content.
Participants were asked to listen to several musical excerpts with different emotional content (sadness, fearfulness and happiness), while physiological responses were recorded. The study revealed distinctive patterns of physiological activity for each type of excerpt, suggesting that the listeners experienced emotional states that corresponded with the emotional content of each piece, and therefore supported the emotivist account.

However, an inherent limitation of Krumhansl’s approach was its reliance on a rigid categorisation of emotional states, and consequently, its implicit assumption about the existence of emotion-specific patterns of physiological arousal. This is problematic because, while some (non-musical) studies have identified physiological correlates of specific emotional states (e.g. Ekman, Levenson & Friesen, 1983; Stemmler, 1989), the patterns of ensuing arousal have been shown to be largely dependent on the particular methods used to elicit emotions in each study (Cacioppo, Klein, Berntson & Hatfield, 1993). Indeed, Krumhansl’s measurements showed only moderate consistency with the physiological patterns found in the aforementioned studies, implying that ‘musical’ emotions are distinct from experientially similar feelings that occur in non-musical contexts.

An alternate approach was taken by Witvliet’s (1997) study of music-prompted physiological effects (including facial EMG, the startle blink, heart rate and skin conductance), which utilised the valence / arousal dimensional framework. Witvliet’s investigation revealed that the physiological changes elicited by listening to emotionally charged music corresponded with listeners’ ratings of valence and arousal, which were found to be consistent with changes observed in previous studies (e.g. Lang et al., 1993). The one exception was the startle reflex magnitude, which
was found to be negatively associated with reported arousal – in contrast to other studies that have suggested the response is potentiated by low valence (i.e. negative) stimuli. Again, the results of this study appeared to support the emotivist account, as the subjects’ valence and arousal self-reports corresponded with the emotions expressed in the musical presentations, which in turn were reflected in the subjects’ physiological responses. Notably, Witvliet also observed that people generally reported greater liking for the high valence presentations, but failed to distinguish whether physiological responses were influenced by valence or enjoyment alone.

The first goal of the present study was to extend the research of Krumhansl and Witvliet by investigating directly the issue of which account (aestheticist, cognitivist or emotivist) best explained the enjoyment of negative emotions in music paradox. To address this question, the relationships between participants’ physiological responses to music and their self-report ratings (of valence, arousal and enjoyment) were examined. In addition, the present study extended the aforementioned research by including a much wider range of musical styles.

**Tough-mindedness and musical preference**

The second goal of the experiment was to investigate the potential moderating effect of the personality characteristic ‘Tough-mindedness’ on the tendency of people to enjoy music of varying emotional content. Tough-mindedness, which is also called Psychoticism (P), is the third dimension of the personality framework of H. J. Eysenck, along with the dimensions of Extraversion (E) and Neuroticism (N).

The P dimension was originally conceptualised by Eysenck (Eysenck & Eysenck, 1976) as a measure reflecting a predisposition to psychotic disorders,
including schizophrenia and bipolar disorder. Since its emergence as a questionnaire in 1975, the P scale has been criticised by numerous authors, most notably for its apparent inability to differentiate psychotic and non-psychotic populations, and its questionable face validity (Bishop, 1977; Block, 1977a,b; Claridge, 1981). For example, Block (1977a) suggested that the P scale might actually be more indicative of aggressive, impulsive and antisocial characteristics than underlying psychotic tendencies. Some have also argued that P should be split across two or more basic factors. In particular, Costa and McCrae’s “Big 5” model of personality has posed a significant challenge to Eysenck’s framework, with these authors suggesting that P might be better represented by two factors from their model (Agreeableness and Conscientiousness), following their discovery of strong negative correlations between P and these dimensions (Costa & McCrae, 1985).

In response to the first of the above criticisms, Eysenck (1977, 1992a) argued that the tendency of psychiatric groups to show elevated ‘Lie’ (L) scale scores was indicative of distortion in the P scores of this population, and re-emphasised that the P scale was designed to measure psychotic tendencies in a “normal” (non-clinical) population. In reply to Costa and McCrae, Eysenck (1992b) pointed to several meta-analyses of personality factorial studies (e.g. Tellegen and Waller, 1991) that suggested three personality domains at the highest level, and criticised the “Big 5” model for its lack of theoretical and biological foundations. He also drew attention to the numerous intercorrelations between the “Big 5” dimensions, and suggested that Agreeableness and Conscientiousness were actually sub-factors that formed part of the higher-order construct of Psychoticism. Eysenck (1992b) argued that the construct validity of the P-scale was supported by a number of experimental and real-life phenomena that differentiate psychotics and normals, as well as high and low P
scorers – including hormonal-biochemical levels, responses to conditioning tasks, performance on various psychological tasks and questionnaires, and physiological functioning.

Of particular relevance to the present study is the apparent resilience of high P scorers to emotional stressors. There is considerable evidence to suggest that high P individuals show less emotional disturbance in stressful situations, as reflected by attenuated physiological responses. Breivik, Roth and Jørgsen (1998) found that P was negatively correlated with heart rate increase before parachuting from a plane. In another physiological study, Stelmack, Plouffe and Falkenberg (1983) evidenced a significantly lesser increase of skin-conductance in high-P participants, in response to emotionally stimulating pictures. Robinson and Zahn (1985) also revealed a tendency of high P scorers to show less autonomic responsivity (using heart rate and skin conductance measures) to two-flash threshold response tasks performed in standing and reclining positions.

With respect to this apparent resilience, a number of researchers (e.g. Eysenck & Eysenck, 1976; Robinson & Zahn, 1985) have suggested that P might represent a lesser form of psychopathy, as well as underlying psychotic behaviour. An absence of exhibited fearfulness has traditionally been viewed as a key characteristic of psychopathy (Fowles, 1980; Hare, 1970; Lykken, 1957). Recently, the tendencies of psychopaths to show blunted emotional and physiological responses to affective stimuli have come under investigation. Patrick, Bradley and Lang (1993) examined the startle reflex responses of sexual offenders to pictorial stimuli. They found that inmates with high psychopathy showed less potentiation of the reflex to unpleasant pictures, compared with non-psychopaths. This finding has since been replicated
using a general prison population (Levenston et al., 2000). The authors of both studies suggested that this inhibition was indicative of a heightened threshold for aversive stimuli in psychopaths, and a possible deficiency in emotional processing.

Another personality characteristic theorised to be linked closely with P is sensation-seeking (SS) (Zuckerman, 1979, 1994), a characteristic reflecting tendencies to pursue novel and intense sensory stimulation. According to Zuckerman (1994), underlying biological mechanisms account for individual differences in SS, with high sensation-seekers motivated to maintain an optimum level of arousal of the catecholamine systems (which are believed to be associated with positive rewards at low levels, and anxiety at high levels). An exploratory study by Eysenck and Zuckerman (1978) suggested that SS was positively correlated with both Psychoticism and Extraversion, as measured by the Eysenck Personality Questionnaire (Eysenck & Eysenck, 1975).

More recently, Glicksohn and Abulafia (1998) examined the relationship between SS and the Eysenck personality dimensions in a combined factor analysis. The analysis revealed that P and three of the four subcomponents of SS (Excitement-Seeking, Disinhibition and Boredom Susceptibility) formed a single higher order factor. The authors identified this as ‘Impulsive Unsocialized Sensation Seeking’, a personality dimension originally conceptualised by Zuckerman (1992) as encompassing both P and SS. This emergent factor appeared to be distinct from Extraversion, supporting Zuckerman’s contention that SS and P were inherently related.

The construct of sensation-seeking has been used in empirical studies of aesthetic preference more than any other measure. High SS individuals have been
observed to exhibit preferences for highly complex and arousing art forms, including tension-evoking paintings (Zuckerman, Ulrich & McLaughlin, 1993), complex polygons (Looft & Baranowski, 1971; Rawlings, Twomey, Burns & Morris, 1998), and hard-rock music (Litle & Zuckerman, 1986; Rawlings, Barrantes i Vidal & Furnham, 2000; Rawlings et al., 1998).

Similarly, several sources of evidence have pointed to a relationship between Tough-mindedness and a preference for hard-rock music, as well as a strong dislike for “soft” popular music. Rawlings et al. (1995) found a correlation between P and liking of hard-rock/heavy metal musical excerpts, and a strong negative correlation between P and easy listening music. The study also revealed that high-P scorers tended to show a preference for dissonant (augmented, atonal and diminished) chords. Robinson, Weaver and Zillmann (1996) evidenced a strong relationship between the enjoyment of hard/rebellious rock-music video clips and P. Finally, McCown, Keiser, Mulhearn and Williamson (1997) found that P was associated with a preference for enhanced bass.

Hard-rock music possesses three distinctive qualities that are likely to be associated with its appeal to tough-minded people. First, themes of rebelliousness and defiance of authority are common within this style of music (Robinson et al., 1996). Because P is partly characterised by lack of socialisation and disrespect for authority figures (Eysenck & Eysenck, 1976), it follows that such music would likely hold personal relevance and appeal to high P individuals. Second, hard-rock music often expresses negative emotions (e.g. despondency, hopelessness, and aggression) that many musical listeners would find inherently unpleasant. However, given that highly tough-minded people tend to be resilient to emotional stressors, it is plausible that
they would have a greater capacity than most people to derive pleasure from this style of music. Finally, hard-rock music is characteristically arousing to the senses, because of its dissonance, volume and power. Since P is strongly associated with sensation-seeking, it is probable that the intense quality of hard-rock would be a major attraction for the highly tough-minded.

This line of reasoning gives rise to two pertinent questions. First, is the appeal of hard-rock music to high P scorers due to a general preference for the style, or is it related to the *emotional content* of this type of music? Second, compared to low-P individuals, would highly tough-minded people show a greater liking for other music styles that were similarly arousing and emotionally unpleasant? This study addresses these questions by comparing the self-report ratings and physiological responses between highly tough-minded (P+) and tender-minded (P-) participant groups for the sound and music presentations. In order to determine the effect of emotional content on the enjoyment of music for each participant group, comparisons were made between the groups for presentations belonging to pre-defined valence × arousal categories.

*The Present Study: Hypotheses*

It was expected that the valence and arousal ratings would be congruent with the specific categories to which we had assigned each sound and music stimulus. Physiological changes that resulted from the non-aesthetic sound presentations were also expected to be consistent with changes observed in previous psychophysiological studies (e.g. Bradley & Lang, 2000a). Specifically, it was hypothesised that: 1) corrugator activity would increase during unpleasant presentations, 2) zygomatic
activity would increase for pleasant stimuli, 3) startle blink magnitudes would be potentiated by unpleasant stimuli and inhibited by pleasant stimuli, 4) greater cardiac deceleration would occur for unpleasant stimuli, and 5) skin resistance would decrease during highly arousing presentations.

With regard to the enjoyment of negative emotions in music paradox, specific hypotheses were formulated for each of the emotivist, aestheticist, and cognitivist accounts. First, the emotivist account purports that emotions experienced while listening to music are the same as everyday emotions. Hence, this standpoint predicts that the relationships between physiological changes and ratings of valence and arousal will be the same as those observed in other studies using non-aesthetic stimuli (as well as the sound samples used in this study). Second, the aestheticist standpoint argues that ‘musical emotions’ are inherently positive, and related to people’s appreciation (or *liking*) for musical pieces. Thus, this account predicts that physiological patterns indicative of positive emotions (i.e. zygomatic EMG activity, corrugator EMG inactivity and startle blink inhibition) will be associated with rated enjoyment, and *not* rated valence. Finally, the (pure) cognitivist account claims that the emotional content of music alone does not stimulate genuine emotions in listeners. Consequently, this account predicts no reliable changes in the physiological responses from baseline levels during presentations of music, based on affective self-reports. However, the more general cognitivist account predicts a possible association between liking and physiology (following a cognitive appraisal of the music’s artistry). Hence, the range of physiological responses predicted by the aestheticist standpoint actually represents a subset of the patterns of responses predicted by the cognitivist account.
In relation to the influence of Tough-mindedness on musical preference, it was predicted that the P+ group would report greater enjoyment than the P- group for the musical stimuli designated to the low valence categories, due to the association between P and emotional resilience. In particular, it was expected that the P+ group would report substantially greater enjoyment for music belonging to the low valence-high arousal category, since hard-rock music is associated with this region of affective space. It was also expected that the P+ group would show less cardiac acceleration, startle magnitudes and GSR activity, in response to both highly stimulating and unpleasant stimuli. Owing to the relationship between P and sensation-seeking, it was predicted that the P+ group would report greater enjoyment than the P- group for highly arousing presentations, and the opposite for stimuli belonging to the low arousal category.

Finally, since highly tough-minded people tend to show a greater appreciation for emotionally negative music styles (such as hard rock) and less enjoyment for some forms of emotionally positive styles (such as easy listening), it was expected that the P+ group’s enjoyment ratings for each musical stimulus would show greater divergence from their valence ratings, compared to the P- group.
Methodology

Participants

Participants were 40 first-year Psychology students from the University of Melbourne, who took part in this experiment as part of a research participation course requirement. They were selected from a pool of volunteers \((N = 322)\) who had participated in a personality screening-project earlier in the year. Based on their P-scale scores in the Eysenck Personality Questionnaire-Revised (EPQ-R; Eysenck, Eysenck & Barrett, 1985), the volunteers were contacted by e-mail and telephone and invited to participate in the present study. The 20 highest and lowest scorers who accepted this invitation were recruited.

The mean P scores for the high (P+) and low (P-) groups were 12.2 and 1.3 respectively, with standard deviations 2.02 and .98. The P scores ranged from 0 to 3 in the P- group, and from 11 to 20 in the P+ group. The maximum P scores for the P- group and minimum for the P+ group corresponded to the 26.7 and 93.3 percentiles of the screening sample respectively, and were 0.89 and 1.45 standard deviations from the screening sample mean \((X = 6.04, s = 3.42)\). Ages ranged from 18 to 32 years, with group means of 19.65 (P-) and 19.45 (P+). Groups did not differ in racial composition (the P+ group included 15 Caucasians and 5 Asians, and the P- group included 14 Caucasians and 6 Asians).

Due to the constraints of the selection process and the greater proportion of females in the screening project, it was unfortunately not possible to provide a gender
balance within and between the groups. Three of the forty chosen participants were male, and these belonged to the high P group.

**Stimulus Materials**

**Sounds and Music**

A series of 18 (non-aesthetic) sounds and 18 musical excerpts were used in this experiment. For both the sound/musical categories, the presentations had been chosen to represent three levels of valence (six pleasant, six neutral, and six unpleasant) and two levels of arousal (nine high arousal, nine low arousal). The excerpts had been selected from an earlier pre-testing process, in which ten colleagues of the author had rated 100 sound and musical clips on the valence and arousal dimensions. Details about the pilot study and the presentations are presented in Appendix 1.

The sound samples were obtained from Bradley and Lang’s (1999) IADS (International Affective Digitized Sounds) CD-ROM of auditory stimuli and from the Internet site WAVcentral.com. The musical excerpts from the Internet site MP3.com as well as the author’s own CD collection. The excerpts were chosen to represent a wide variety of musical styles, with the majority being lesser-known pieces in order to minimise the possibility of effects related to prior associations. In order to provide a broad musical variety, approximately half of the half of the music presentations in each category contained vocals (see Appendix 1).

Each excerpt was edited digitally to a 11.5 second presentation, which involved the looping of the sound samples. This particular length was chosen partly because of technological limitations in the software package used to present the stimuli, but also because previous physiological studies using auditory stimuli (e.g. Bradley & Lang,
2000a) have tended to use presentations under ten seconds to considerable success. The average peak volumes of the sound and music presentations were 89.25dB (SD = 3.42) and 91.47dB (SD = 6.83), respectively. The volumes varied with respect to the sounds’ natural volumes in the environment (e.g. the sound of a jet was louder than singing birds), and the style of music (e.g. hard rock was louder than easy listening). The presentations were converted to 16-bit monophonic .WAV files, at 22500 Hz.

The stimuli were presented using Pioneer SE 4000 stereo headphones attached to the speaker (SPK) output of a Sound Blaster AWE64 (Value Edition) sound card, in an IBM-compatible computer. The sequence and timing of the presentations were controlled by the software package Virtual Psychophysiology Monitor Program (VPM; Cook, 2000). Before the experiment, two random sequences of stimuli were generated to minimise the possible impact of order effects. Half of the participants in each P group listened to the presentations in one order, while the rest were exposed to the alternate sequence.

**The Startle Probe**

The startle probe consisted of a 50msec burst of 108.2dB white noise with immediate rise time, which was presented binaurally through headphones at 3.0, 5.5, 8.0, or 10.5 seconds after stimulus onset, for all presentations. The probe was also presented after a third of the stimuli, following delays of 3, 4, 5, 6, or 7 seconds. The delays corresponded to the sequences generated before the experiment, and were identical for participants using the same sequence.
**Psychological Measurement**

The participants were asked to rate their experiences of each presentation on four separate scales: 1) valence (feelings of emotional pleasantness versus unpleasantness), 2) arousal (tranquility versus stimulation and excitement), 3) familiarity (level of recollection for the presentation), and 4) enjoyment (liking versus disliking of the presentation).

Valence and arousal ratings were obtained using a computerised version of the Self-Assessment Manikin (SAM) (Lang, 1980). This rating system uses a graphical figure, whose expression can be altered to represent levels of valence and arousal (reproduced in Figure 1). Custom-designed scales were used for the measures of familiarity and enjoyment. In rating each stimulus, participants used a controller-box to manipulate the interactive display, which was controlled by a second IBM-compatible computer.

![Self-Assessment Manikin (SAM) scales of valence and arousal](image)

Figure 1. The Self-Assessment Manikin (SAM) scales of valence and arousal, adapted from Bradley & Lang (1999, p. 11).
Physiological Measurement and Data Processing

For each participant, five physiological measures associated with emotional responses were taken: startle reflex modulation, facial electromyographic (EMG) activity (in the zygomatic and corrugator muscle groups), galvanic skin response (GSR), and heart rate.

Physiological signals were recorded using Grass bioelectric recording equipment linked to an IBM compatible microcomputer via a PC-Labcard 812-PG analog-to-digital converter. The VPM software package (Cook, 2000) controlled the timing and presentation of the stimuli, and the collection and storage of the physiological and self-report data. For each trial, physiological signals were recorded over a 23.5 second period (including a 2s baseline interval, the 11.5s presentation, and a 10s post-stimulus interval). The physiological signals were processed and analysed following the experiment.

Startle Magnitude

The eye blink component of the startle response was recorded unilaterally by measuring the EMG activity from the obicularis oculi muscle beneath each participant’s right eye. A pair of electrodes was placed below the eye, in the positions specified by Cacioppo and Tassinary (1990) (see Figure 2). The raw EMG signals from the obicularis oculi muscle were amplified and filtered (half amp. high and low frequency cutoffs were 10kHz and 10Hz respectively) using a Grass 7P511 amplifier. Blink responses were sampled at 1,000Hz.

The digitized raw EMG from the startle blink was integrated (i.e., full-wave rectified and low pass filtered with a time constant of 50ms) offline. Startle responses
were scored with the VPM software package (Cook, 2000), using the algorithm of Balaban, Losito, Simons and Graham (1986). Blink magnitudes were scored as the distances between the peak and baseline activity levels. Startle probes were presented during all of the trials, and in the interval following one third of the presentations to obtain a baseline measure. Mean baseline magnitudes were calculated separately for the sounds and music items.

The raw blink scores were standardised within each participant to decrease variability due to differences in the absolute size of the startle blinks across all participants. This was done separately for the sound and music items. Ratio scores (i.e. the in-trial magnitudes divided by the mean baseline magnitudes) were used in the between-groups analyses. Startle data from four participants, as well as a proportion of the data from another two (only in the music condition), were discarded because of equipment failure.

**Heart Rate**

Heart rate was measured by placing electrodes on the upper forearms of both arms, with the ground electrode on the “non-dominant” foreleg. The signal was amplified by a Grass 7P511 AC amplifier with the “half amp low frequency” filter set to 100Hz and the “half amp high frequency” filter set to 1kHz, and sensitivity set at 7.5 μV/mm. This signal was sampled at 1,000Hz, and was applied to a Schmitt trigger, a device that detects the R component of the cardiac waveform, and produces a TTL level pulse which interrupts the computer program on each heart beat with a resolution of 1 millisecond.

The beat data were filtered using a VPM editing tool designed to detect improbable beat intervals. Following this procedure, cardiac inter-beat intervals were
converted into a beats-per-minute format in half-second epochs, weighting each interval by the fraction of the epoch time that it occupied. From the interval data, mean baseline and in-trial beat-rate scores were calculated, which were used in the later analyses. One participant’s heart rate data was excluded from the analysis, due to excessive noise within the signal.

**Facial Electromyographic (EMG) Activity**

Facial muscle activity was measured by placing electrodes over the corrugator supercilli (corrugator) and zygomatic major (zygomatic) muscles in the positions specified by Cacioppo and Tassinary (1990) (see Figure 2). The signals were amplified and filtered as described above for the startle response, except that facial EMG signals were recorded for the entire duration of each sound and music presentation.

In the analyses, facial muscle activity was represented by the average integrated activity (i.e., full-wave rectified and low pass filtered with a time constant of 500msec) from each site over the duration of the sound/music presentations, after subtraction of the mean activity for the 2-second pre-stimulus (baseline) period. Because a startle probe was presented in every trial, we considered it acceptable to use the EMG data recorded over the entire duration of the presentations in the analyses, rather than a subset of this data. We also theorised that music might take longer than sounds to induce an emotional reaction, so we opted to use data recorded over the entire presentation.
Skin Resistance Responses

Skin resistance was recorded by two Ag/AgCl electrodes, placed on the thenar and hypothenar eminences of the non-dominant hand, and connected to a Grass 7P122 DC amplifier. See Figure 3 for skin resistance response electrode placement. Mean baseline (pre-stimulus) and in-trial skin resistance levels were extracted from the GSR data, following the experiment. The baseline measures were subtracted from the in-trial measures to obtain change scores, which were later used in the statistical analyses. Since this measure reflects changes to electrical resistance, negative scores represented an increase in skin conductivity due to greater sweatiness, and hence, an increase in autonomic arousal.
Figure 2. Facial EMG electrode placement, adapted from Cacioppo & Tassinary (1990, p. 344)

Figure 3. Skin Resistance Response Electrode Placement, adapted from Cacioppo & Tassinary (1990, p. 302)
Procedure

After signing the consent form, each participant was taken into a well-lit, isolated room containing the physiological apparatus. They were seated in a comfortable chair, in front of a television displaying the interactive rating interface.

The participants were informed that they would be listening to a series of sound and music presentations, and that they would be asked to rate each on the scales of valence, arousal, familiarity and enjoyment. Each of the scales was explained in detail (see Appendix 2 for the instruction sheet), and the participants were instructed how to use the computerised rating system. In particular, it was emphasised that the valence and arousal ratings were supposed to reflect how the presentations made them feel, not whether the excerpts contained these qualities. A clear distinction was also drawn between the valence and enjoyment scales. Participants were given explicit instructions to use the valence scale to reflect the degree to which they felt positive or negative emotions after listening to each presentation, and the enjoyment scale to indicate how much they liked or disliked each piece.

The electrodes were then attached to each participant in their appropriate positions, and headphones placed on their ears. Following this process, they were given four example presentations (two sound, two music) to reinforce their memories of the rating instructions and to habituate them to the startle probe.

When the experimenter was satisfied that the participants understood the instructions, the sounds and then musical excerpts were presented over the headphones in one of the two pre-generated order sequences. During each presentation, the physiological measurements were recorded from the participants. At
the end of each presentation, participants rated that excerpt using the five self-report scales before the commencement of the next trial.

Following the completion of the experiment, the participants were unhooked from the electrodes, debriefed (see Appendix 3 for the debriefing form), given their course credit, and thanked.

**Data Reduction**

As stated previously, each sound and musical stimulus was assigned to one of six *a priori* categories, according to how participants in the pre-testing study had rated it. The categories comprised three valence levels (low / neutral / high) by two arousal levels (low / high). Within these categories, mean self-report ratings and physiological changes were calculated for each participant. This was done separately for the sounds and music.

In a second part of the analysis, the musical presentations were assigned to three *empirical* enjoyment categories (low, medium and high), based on their mean enjoyment ratings across participants. This was done to examine the relationship between the enjoyment self-report rating and the associated physiological responses of each participant, and consequently to address the hypotheses relating to the enjoyment of negative emotions paradox.

Finally, to determine the correspondence between the valence and enjoyment ratings, absolute differences were calculated between these ratings for every musical excerpt. A total was calculated for each participant, which was intended to reflect that participant’s overall disparity between emotional pleasantness and enjoyment.
Results

Adequacy Checks

Before any analyses were conducted, the self-report and physiological data were checked for departures from normality, using one-sample Kolmogorov-Smirnov tests and normal probability plots. Transformations were made where deemed necessary, and are detailed before each analysis. Statistics depicted in graphs are based on the untransformed data.

All repeated-measures analyses were tested for violations of sphericity. When a violation occurred, the Greenhouse-Geisser Epsilon ($\varepsilon$) value was used to adjust the degrees of freedom. In such instances, $\varepsilon$ is reported with the original degrees of freedom.

In all analyses, an alpha level of .05 was used in determining significance. Values of $p$ less than .10 were classified as non-significant trends.

Comparisons Across A Priori Categories and Between P+/- Groups for Sounds

To assess the correspondences between the a priori categories and the self-report / physiological measures, each variable was compared across the categories using a series of 3 (valence) $\times$ 2 (arousal) repeated-measures analyses of variance (ANOVA), with P as a between-groups factor. Independent-samples t-tests were used to make direct comparisons between the P+/- groups within each a priori category, where relevant to the research hypotheses (i.e. for the startle, heart rate and skin resistance data).
The outcomes of each ANOVA are presented in Table 1. Figures 4 through 10 illustrate the relationships found in Table 1, as well as the between-group differences within each \textit{a priori} category. The category means for each variable are tabled in Appendix 4, and the P+/- comparisons in Appendix 5.
Table 1.
Analysis of variance for self-report and physiological variables in the sound condition, across *a priori* valence and arousal categories and between the P+/P− groups.

<table>
<thead>
<tr>
<th></th>
<th>df</th>
<th>Rated Valence</th>
<th>Rated Arousal</th>
<th>Corrugator EMG</th>
<th>Zygomatic EMG</th>
<th>Startle Reflex</th>
<th>Heart Rate</th>
<th>Skin Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Between subjects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>Psychoticism Group (P)</td>
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<td>&lt; 1</td>
<td>&lt; 1</td>
<td>4.14*</td>
<td>n/a</td>
<td>&lt; 1</td>
<td>1.57</td>
</tr>
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<td>P within group error</td>
<td>38</td>
<td>(8.12E+05)</td>
<td>(15.36)</td>
<td>(121.19)</td>
<td>(1.95E+06)</td>
<td>n/a</td>
<td>(30.38)</td>
<td>(1.7E+15)</td>
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<tr>
<td><strong>Within subjects</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valence Category (V)</td>
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<td>69.73***</td>
<td>28.76***</td>
<td>6.01**</td>
<td>2.85(*)</td>
<td>11.44***</td>
<td>3.68*</td>
<td>0.07</td>
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<td>V × P</td>
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<td>4.18*</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
<td>1.27</td>
<td>0.99</td>
<td>&lt; 1</td>
<td>0.18</td>
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<td>V within group error</td>
<td>76</td>
<td>(9.46E+05)</td>
<td>(2.81)</td>
<td>(70.97)</td>
<td>(2.36E+06)</td>
<td>(0.29)</td>
<td>(8.88)</td>
<td>(5.1E+14)</td>
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<td>Arousal Category (A)</td>
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<td>1.81</td>
<td>24.52***</td>
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<td>&lt; 1</td>
<td>&lt; 1</td>
<td>1.41</td>
<td>20.63***</td>
</tr>
<tr>
<td>A × P</td>
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<td>1.37</td>
<td>1.11</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
<td>3.47(*)</td>
<td>&lt; 1</td>
<td>3.57(*)</td>
</tr>
<tr>
<td>A within group error</td>
<td>38</td>
<td>(5.25E+05)</td>
<td>(4.78)</td>
<td>(54.35)</td>
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<td>(5.79E+14)</td>
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<td>V × A</td>
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<td>&lt; 1</td>
<td>6.94**</td>
<td>1.33</td>
<td>0.41</td>
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<td>2</td>
<td>&lt; 1</td>
<td>3.14*</td>
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<td>&lt; 1</td>
<td>1.28</td>
<td>&lt; 1</td>
<td>2.40(*)</td>
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<td>V × A within grp. error</td>
<td>76</td>
<td>(5.87E+05)</td>
<td>(4.03)</td>
<td>(125.74)</td>
<td>(1.5E+06)</td>
<td>(0.24)</td>
<td>(10.12)</td>
<td>(4.45E+14)</td>
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</table>

*Note.* Values enclosed in parentheses represent mean square errors. Some of the mean square error statistics are reported in scientific numbers, due to their extremely large size. For example, 8.12E+05 ≈ 812000.

*df = 68,*  *df = 34,*  *df = 37,*  *df = 74

(*) *p < .10.  * *p < .05.  ** *p < .01.  *** *p < .001.
Self-Report Ratings (Sounds)

Rated valence scores were subjected to a cubic ($X^3$) transformation to correct for non-normality. Using the transformed data, valence was found to vary significantly across the valence categories, indicating that the participants’ valence ratings corresponded with the \textit{a priori} categories as expected (see Figure 4). While no significant main effects for group were found, a valence by group interaction was observed such that the P+ group reported lower valence ratings in the high valence category (see Figure 4).

![Figure 4](image-url)

\textbf{Figure 4.} Mean (untransformed) valence ratings across the arousal \textit{a priori} valence categories, ordered by arousal category and P+/− groups. Error bars indicate standard error of means.
As expected, rated arousal varied significantly over the arousal categories (see Figure 5). A significant effect was also found for valence category (as well as a valence by arousal interaction), with the pleasant and unpleasant valence categories containing the overall highest rated arousal.

![Figure 5](image)

**Figure 5.** Mean arousal ratings across the arousal *a priori* valence categories, ordered by arousal category and P+/− groups. Error bars indicate standard error of means.
Physiological Measures (Sounds)

In accordance with expectations, corrugator EMG activity was observed to vary significantly across the valence categories, with corrugator activity increasing with unpleasantness (see Figure 6). No effects for arousal or group were found.

![Figure 6](image.png)

Figure 6. Mean corrugator activity across the arousal *a priori* valence categories, ordered by arousal category and P+/- groups. Error bars indicate standard error of means.
To correct for non-normality, zygomatic EMG change scores were squared (following an additive transformation to eliminate negative values). Using the transformed data, a non-significant trend was found for valence category, but a planned quadratic contrast revealed a significant effect ($F_{1,38} = 4.396$, $p = .043$), which was still consistent with expectations (see Figure 7). A significant group effect was also observed, with the P- group showing higher overall activity.

![Figure 7](image-url)

**Figure 7.** Mean (untransformed) zygomatic activity across the arousal *a priori* valence categories, ordered by arousal category and P+/- groups. Error bars indicate standard error of means.
As expected, the standardised startle scores varied significantly over the valence categories, with magnitudes increasing during unpleasant presentations. While no significant effect was found for arousal category, a significant valence by arousal interaction was discovered (see Figure 8). Independent-samples t-tests conducted on the non-standardised data revealed a significant difference between the groups only in the Neutral Valence-Low Arousal category ($t_{34} = 2.152$, $p = .039$), with the P+ group exhibiting a greater blink magnitude.

![Figure 8. Mean (standardised) startle blink magnitudes across the arousal a priori valence categories, ordered by arousal category and P+/- groups. Error bars indicate standard error of means.](image-url)
Analysis of heart-rate change revealed a significant main effect for valence category. Contrary to expectations, greater cardiac deceleration occurred in the neutral and pleasant conditions (see Figure 9). No significant main effect was found for arousal, or group. Independent-samples t-tests failed to reveal significant differences between the groups in any of the categories.

Figure 9. Mean heart rate acceleration across the arousal \textit{a priori} valence categories, ordered by arousal category and P+/− groups. Error bars indicate standard error of means.
Skin resistance change scores were subjected to a cubic transformation (following an additive transformation to remove negative values), to correct for non-normality. Using the transformed data, a highly significant effect was found for arousal category, with skin resistance showing the greatest decrease in the high arousal categories as expected (see Figure 10). No significant main effects were found for valence or group; however, the P+ group showed significantly less GSR activity in the High Valence-High Arousal category ($t_{38} = 2.855, p = .008$).

![Figure 10](image)

**Figure 10.** Mean skin resistance change across the arousal *a priori* valence categories, ordered by arousal category and P+/- groups. Error bars indicate standard error of means.
Comparisons Across A Priori Categories and Between P+/- Groups for Music

A series of similar $3 \times 2$ repeated measures analyses of variance were performed for the musical stimuli. Independent-samples t-tests were again used to make direct comparisons between the P+/- groups within each category, for the startle, heart rate and skin conductance measures, as well as the enjoyment ratings.

The outcomes of each ANOVA are presented in Table 2. Significant category and between-group effects are illustrated in Figures 11 through 15. The category means for each variable are presented in Appendix 4, and the P+/- comparisons in Appendix 5.
Table 2.  
Analysis of variance for self-report and physiological variables in the music condition, across *a priori* valence and arousal categories and between the P+/P- groups.

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<td>11.06**</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
<td>29.70***</td>
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<td>&lt; 1</td>
<td>11.37**</td>
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<td>V × A</td>
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<td>&lt; 1</td>
<td>&lt; 1</td>
<td>15.33***</td>
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<td>V × A × P</td>
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<td>ε = .783</td>
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<td>ε = .822</td>
<td>ε = .822</td>
<td>ε = .822</td>
<td>ε = .822</td>
<td>ε = .822</td>
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<tr>
<td>V × A within grp. error</td>
<td>76</td>
<td>(3.37)</td>
<td>(2.38)</td>
<td>(5.20)</td>
<td>(52.63)</td>
<td>(165.29)</td>
<td>(0.26)</td>
<td>(9.70)</td>
<td>(1493.56)</td>
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<td>ε = .783</td>
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<td>ε = .822</td>
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</tr>
</tbody>
</table>

Note. Values enclosed in parentheses represent mean square errors.

*a* df = 64,  
*b* df = 32,  
*c* df = 37,  
*d* df = 74

(*) *p < .10.  
*p < .05.  
**p < .01.  
***p < .001.
Self-Report Ratings (Music)

As expected, valence ratings varied significantly across the valence categories. No significant main effect for arousal was observed; however, a significant valence by arousal interaction was observed (see Figure 11). Valence ratings differed significantly between groups, with the P+ group reporting uniformly lower ratings within each category.

![Figure 11. Mean valence ratings across the arousal a priori valence categories, ordered by arousal category and P+/− groups. Error bars indicate standard error of means.](image)
Arousal ratings varied significantly across the *a priori* arousal categories, as expected (see Figure 12). No significant main effects for valence category or group were uncovered.

**Figure 12.** Mean arousal ratings across the arousal *a priori* valence categories, ordered by arousal category and P+/− groups. Error bars indicate standard error of means.
Statistical analysis of the enjoyment ratings revealed significant main effects for both valence and arousal categories, with greatest enjoyment reported in the Neutral and High Valence categories, and in the Low Arousal category (see Figure 13). A significant valence by arousal interaction was also discovered. No significant main effects were found for group; however, significant valence by group and arousal by group interactions were uncovered, such that the P- group reported particularly low enjoyment for the Low Valence-High Arousal category.

![Figure 13. Mean arousal ratings across the arousal a priori valence categories, ordered by arousal category and P+/− groups. Error bars indicate standard error of means.](image)

To address the research hypotheses related to the influence of P on enjoyment, comparisons were made between the enjoyment levels of the P+/− groups in each category. Since rated enjoyment was highly correlated with familiarity within almost
all of the categories (a table of these correlations is included in Appendix 7),
regression analyses were performed for each category, predicting enjoyment from
familiarity. From each analysis, residual values were extracted and compared
between the P+/− groups using independent-samples (one-tailed) t-tests.

As expected, the P+ group reported significantly less enjoyment in the Low
Arousal-Neutral Valence category \(t_{38} = -3.944, p < .001\), and the Low Arousal-High
Valence category \(t_{38} = 2.014, p = .025\). In addition, the P+ group reported
significantly greater enjoyment in the High Arousal-Low Valence category \(t_{38} = -1.956, p = .029\), but not in the High-Arousal-Neutral Valence category \(t_{38} = .748, p = .230\) or the High Arousal-High Valence \(t_{38} = -.468, p = .322\). A two-tailed test
was performed for the Low Arousal-Low Valence category, since it had been
concurrently predicted that the low arousal categories would stimulate less enjoyment
in the P+ group, and that the low valence categories would produce greater
enjoyment. This comparison was found to be non-significant \(t_{38} = -.954, p = .346\).
Physiological Measures (Music)

Analysis of corrugator and zygomatic EMG activity revealed no significant main effects for valence, arousal, or group. For the startle reflex scores, no significant effects for valence were found. However, a strong effect was found for arousal, with the greatest startle potentiation occurring in the low arousal category (see Figure 14). Using the unstandardised startle scores, no significant effect for group was observed ($F_{1,32} = .152, p = .700$). Direct comparisons between the P+/− groups using independent-samples t-tests also failed to reveal any significant differences.

Figure 14. Mean (standardised) startle magnitudes across the arousal a priori valence categories, ordered by arousal category and P+/− groups. Error bars indicate standard error of means.
Statistical analyses of heart rate change also failed to show significant main effects for valence, arousal, and group. Direct comparisons between groups also failed to yield any significant differences for any of the categories.

For skin resistance, a significant main effect was found for arousal, with skin resistance showing the greatest decrease in the high arousal category as expected. No significant main effect was found for valence or group, however, a significant valence by group interaction was discovered (see Figure 15). A one-tailed t-test revealed that the P+ group showed significantly less GSR activity in the Low Valence-Low Arousal category ($t_{38} = 1.941, p = .031$), however, this effect did not appear in any of the other categories.

**Figure 15.** Mean skin resistance change across the arousal *a priori* valence categories, ordered by arousal category and P+/- groups. Error bars indicate standard error of means.
Comparisons Across Empirical Enjoyment Categories

The next phase of analysis comprised a series of comparisons between the self-report and physiology variables, across the three empirical enjoyment categories. These analyses were performed using a three-level repeated-measures analysis of variance (ANOVA). The outcomes of each analysis are reported in Table 3. The means and standard deviations of each variable are presented in Appendix 6. Figures are presented only where significant results were found.

### Table 3.
Analysis of variance for self-report and physiological variables in the music condition, across empirical enjoyment categories

<table>
<thead>
<tr>
<th>Enjoymen Category (E)</th>
<th>Rated Valence</th>
<th>Rated Arousal</th>
<th>Rated Enjoyment</th>
<th>Corrugator EMG</th>
<th>Zygomatic EMG</th>
<th>Startle Reflex</th>
<th>Heart Rate</th>
<th>Skin Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>df</td>
<td>2</td>
<td>77.73***</td>
<td>36.80***</td>
<td>1.09</td>
<td>1.23</td>
<td>14.56***</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
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<td>ε = .841</td>
<td>ε = .845</td>
<td>ε = .858</td>
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<td>ε = .845</td>
<td>ε = .845</td>
<td>ε = .845</td>
</tr>
<tr>
<td>E within group error</td>
<td>76</td>
<td>(2.19)</td>
<td>(4.11)</td>
<td>(26.81)</td>
<td>(74.42)</td>
<td>(0.18)</td>
<td>(4.05)</td>
<td>(1055.67)</td>
</tr>
</tbody>
</table>

**Note.** Values enclosed in parentheses represent mean square errors. 
(*) p < .10. * p < .05. ** p < .01. *** p < .001.
As intended, rated enjoyment was found to vary significantly across the empirical categories. Valence was also observed to vary significantly over the categories, with reported valence greatest in the high enjoyment category, followed by the neutral category. An extremely strong category effect was found for rated arousal, with the highest arousal reported in the low enjoyment category (see Figure 16).

Figure 16. Mean valence, arousal and enjoyment self-report ratings across the empirical enjoyment categories. Error bars indicate standard error of means.
Analysis of the corrugator and zygomatic EMG measures revealed no significant category effect. Heart rate and skin resistance also did not vary significantly across the enjoyment categories. In contrast, a highly significant category effect was found for the startle magnitudes, with the highest magnitudes occurring in the medium enjoyment category, followed by the high enjoyment category (see Figure 17).

Figure 17. Mean (standardised) startle magnitudes across the empirical enjoyment categories. Error bars indicate standard error of means.
Comparing the overall tendencies of the P+/- groups to enjoy negative emotion in music (and to dislike emotionally positive music)

High correlations were discovered between ratings of valence and enjoyment for the majority of the musical categories (shown in Appendix 7), indicating that the participants tended to show greater enjoyment for music that was emotionally positive, and dislike for music expressing negative emotions. To compare this tendency between groups, absolute difference scores were calculated between each participant’s valence and enjoyment scores for every musical excerpt to obtain discrepancy scores. The mean discrepancy scores of each participant were compared across the P+/- groups using a one-way analysis of variance (ANOVA). This analysis, however, did not reveal a significant difference between the groups ($F_{1,38} = 1.83, p = .671$).
Discussion

The first aim of the study was to address the issue of why it is possible to enjoy the experience of negative emotions in music, by determining the nature of participants’ emotional responses to music through the measurement of physiological reactions. In response to the non-aesthetic (sound) stimuli, reliable physiological changes were observed that varied with the pleasantness and intensity of the stimuli, consistent with prior expectations. However, these associations were not present for the musical stimuli, suggesting that music does not stimulate discernible emotional reactions (as reflected by physiological changes) in the same manner as sounds. These findings therefore supported the cognitivist explanation for the enjoyment of negative emotions in music paradox.

The second goal was to determine whether Tough-mindedness influenced the enjoyment of music with negative emotional content. The findings of this study suggest that, compared to tender-minded individuals, highly tough-minded people show a slight preference for unpleasant and highly arousing music, and a marked dislike of emotionally ‘bland’ music. These differences in preference were not reflected in any of the physiological measures.

Sounds – Relationships between valence/arousal and physiology

The relationships between the a priori categories and participants’ responses generally conformed to our expectations. The participants’ ratings of valence and arousal for each item were consistent with the categories to which the items had been
assigned, with significant differences observed across the valence and arousal categories, respectively.

The physiological variables were also observed to vary significantly across the categories, consistent with our expectations and previous psychophysiological studies (e.g. Lang et al. 1993). Corrugator EMG activity was shown to increase during presentations of unpleasant (low valence) sounds, and decrease for pleasant (high valence) sounds. Zygomatic activity increased substantially during presentations of pleasant stimuli, dropped below baseline levels for neutral stimuli, and showed a slight increase for unpleasant stimuli. The startle blink decreased linearly with valence, with the largest blinks occurring in the low valence category, and the smallest in the high valence category. Skin resistance was greatest in the low arousal category, and decreased in the high arousal category.

Heart rate was the only measure that deviated from our expectations, with the greatest deceleration occurring in the neutral and high valence categories. This outcome was contrary to the findings of earlier pictorial studies (Lang et al. 1993; Bradley et al., 1990; Greenwald et al., 1989), which all reported greater deceleration for low valence stimuli. Since the present study measured heart rate over a longer duration (11.5s versus 6s), it is possible that our measurements were influenced by changing cardiac activity in the later interval (e.g. relaxation following the recognition of a stimulus).

The majority of these results were consistent with the findings of Bradley and Lang’s (2000a) study that used similar auditory stimuli, as well as those of the aforementioned pictorial studies. These findings suggest that the sounds used in this
experiment were successful in eliciting emotional reactions, as reflected by physiological changes.

**Music – Relationships between valence, arousal and enjoyment, and physiology**

The participants’ self-report valence and arousal ratings generally conformed to our prior expectations, with strong correspondences observed between the ratings and the *a priori* categories. The ratings clearly distinguished the low/neutral/high valence categories and the low/high arousal categories, indicating that the musical selections were successful in representing the intended range of emotions. Enjoyment also appeared to be strongly influenced by both sets of categories, with reported liking increasing in the neutral/high valence and low arousal categories.

In contrast to the sound condition, the majority of the physiological measures did not vary significantly across the *a priori* categories. Corrugator and zygomatic EMG did not appear to be influenced by the valence categories, contrary to expectations. Likewise, heart rate was not modulated by either the valence or arousal categories. The only measure that conformed to our expectations was skin resistance, which decreased significantly for items in the high arousal categories.

Interestingly, the startle blink appeared to be unaffected by valence and modulated by *arousal*, with the largest blinks occurring in the low arousal category. This finding could be due to the higher volumes of the arousing excerpts, which might have diminished the impact of the startle probe. However, this explanation is problematic, since the same effect was observed in Witvliet’s (1997) study, which presented the probes *after* the stimuli. A second possibility is that the response was modulated by attention, given that arousing stimuli are intrinsically engaging. Again,
this explanation is problematic, since blink responses have been evidenced to intensify with increased attention to the sensory modality of the startle probe (Anthony & Graham, 1985). A third possibility is that the arousing music evoked a unique affective state that attenuated the startle blink, such as the inherently pleasurable ‘musical emotion’ suggested by proponents of the aestheticist position (Gurney, 1966; Langer, 1942; Bell, 1914).

The empirical enjoyment categories also failed to distinguish levels of physiological activity. Corrugator and zygomatic EMG, heart-rate and skin resistance did not vary significantly between the conditions. The one exception was the startle reflex, which varied significantly across the enjoyment categories – with the highest magnitudes occurring in the neutral enjoyment category. Again, emotional arousal (manifested in either strong disliking or enjoyment) appeared to be associated with attenuated startle responses.

With regard to the three standpoints on the enjoyment of negative emotions in music paradox, it was surmised that the physiological measures would substantiate the emotivist account if they were found to be indexed by valence, the aestheticist account if they were indexed by enjoyment, and the cognitivist account if no correspondences were observed. Since the musical stimuli generally failed to elicit distinctive physiological changes across the a priori and empirical categories, these findings collectively support the cognitivist account – that emotion is perceived within music, but not correspondingly experienced. This conclusion is strengthened by the fact that the physiological measures were found to differ significantly across the categories in the sound condition, suggesting that emotional sounds and music elicit qualitatively different types of affective responses.
In comparing the P+/- groups, it was initially expected that the P+ group would show a greater preference for music appearing in the low valence categories (owing to the emotional resilience of high P individuals and the possible link between P and psychopathy), and less enjoyment for music in the low arousal categories (due to the association between P and sensation-seeking).

The P+ group reported slightly greater enjoyment for music within the Low Valence-High Arousal *a priori* category. The outcome might be explained by the resilience of high P individuals to emotional stressors (although no significant physiological differences were observed between groups). Alternatively, the P+ group might simply have preferred the styles of music within this category (which contained one heavy techno and two hard-rock excerpts). Since this reported preference did not extend to the Low Valence-Low Arousal category, the prediction that the P+ group would show a general preference for emotionally negative music was not supported.

The most ostensible difference between the P+/- groups was found in the Neutral Valence-Low Arousal category (which contained music that might be considered emotionally ‘bland’), where the P+ group reported substantially less enjoyment than the P- group. The high P group also reported less enjoyment for music within the High Valence-Low Arousal category. These findings were consistent with the evidence that high P individuals dislike less intense ‘easy-listening’ music as suggested by Rawlings et al. (1995), and that sensation-seeking is strongly associated with tough-mindedness (Eysenck & Zuckerman, 1978; Glicksohn & Abulafia, 1997). While this outcome did not extend to the low valence category,
these results generally supported the prediction that the P+ group would show a greater dislike for non-arousing music, and implies that high P individuals generally require a higher level of stimulation to enjoy music.

The comparison of the valence/enjoyment discrepancy scores between the groups suggested that high P individuals were generally not more likely to enjoy low valence music or to dislike music of positive emotional content. Likewise, there was little variation observed between the groups in the heart rate or skin resistance measures within any of the categories.

The startle reflex also did not vary between groups for the music or sound conditions. This result was inconsistent with the studies of Patrick et al. (1993) and Levenston et al. (2000), which observed differences between the responses of psychopaths and non-psychopaths to unpleasant stimuli. The failure to replicate this finding raises some doubt about the link between psychopathy and P suggested by Robinson and Zahn (1985). However, the inconsistency might be due to the fact that both of the aforementioned studies used an all-male sample of criminal inmates, whereas this study used a largely female sample.

In sum, these results suggest that the differences between P+/- preferences were related principally to the arousing quality of music (and possibly musical style), and less to the emotional pleasantness or unpleasantness of the excerpts.

**Methodological Considerations**

A number of methodological issues are considered within this section, related to the ecological validity of the experimental setting, the limitations of emotional measurement, and the sample used in the study.
An obvious criticism is the fact that the experimental procedure took place in an unnatural setting, and hence, might not have produced emotional reactions normally experienced while listening to music. In particular, since the musical stimuli were brief, participants would have been forced to rely solely on instantaneous affective cues to recognise emotions within each presentation, rather than slower emotional build-ups over entire works. However, given that the sound stimuli were successful in eliciting physiological responses under the same conditions, it is reasonable to assume that the laboratory context was appropriate for prompting emotional responses to musical stimuli. Therefore, the failure to do this was probably due to inherent differences in the expressive qualities of sounds and music.

The failure of the musical stimuli to elicit physiological changes might also be related to the fact that the a priori valence and empirical enjoyment categories did not reflect the breadth of the valence and enjoyment scales (which ranged from 0 to 20). The means of the low, medium and high categories were 9.3, 11.1 and 12.25 (for valence), and 9.8, 12.1, and 13.7 (for enjoyment). Thus, most of the stimuli in the low categories clustered around the middle of the valence and enjoyment scales, suggesting the participants experienced medium affective valence and enjoyment, rather than substantial unpleasantness and dislike as intended.

Another possibility is that the participants adopted a different rating strategy within the music condition. For example, they might have mistakenly used the ratings to indicate the emotions they perceived within the music (rather than their own emotional experiences), or not understood the distinction between the valence and enjoyment ratings. These scenarios are unlikely, given that specific verbal and written directions were given to participants instructing them how rate the stimuli. In
addition, dummy familiarity and enjoyment scales were added to the sound condition, to make the rating systems as similar as possible.

A limitation of this study was the fact that only short-term emotional responses were considered. While music did not appear to prompt physiological reactions in the same manner as sounds, it is nevertheless possible that the emotional content of music exerts an effect on the listener’s mood. Short presentations were used in this study in order to replicate the psychophysiological paradigm of Bradley and Lang (2000a), and due to technological constraints. The brevity of the excerpts precluded a longer-term examination of the emotional effects of music, and how emotions change over the progression of a musical piece. Notably, Witvliet’s (1997) study evidenced discernible physiological changes in response to music, using longer (26s) musical samples. Future research might benefit from using longer samples, and measuring physiological changes over an extended period.

Several issues are also related to the sample used in this study. First, the sample size was comparatively small for a between-groups design, and several of the participants’ startle data had to be discarded. As shown in the previous section, several of the effects came close to statistical significance, which would likely have been stronger with a larger sample. Second, the sample contained a greater proportion of females, which may have implications for the generalisability of the results. Finally, since the P groups were derived from extreme P-scale scores, it is possible that the group differences were due to measurement error, rather than genuine individual differences. This was considered unlikely, given that the P score means for both groups fell within two standard deviations of the screening sample mean.
Conclusions

The findings of this study indicate that sounds stimulate physiological and emotional responses in much the same way as affective pictures. In contrast, physiological responses to musical stimuli do not appear to be indexed by valence or enjoyment (although increased GSR activity was observed to occur with reports of high arousal). The results of this study therefore support the cognitivist account – that we do not experience the same emotions that we recognise in music.

The comparisons of the P groups suggest that low and high P individuals do not differ in their physiological responses to music, but do vary in their enjoyment for music of specific emotional content. Specifically, high P individuals show greater enjoyment for unpleasant music that is highly stimulating, and a strong disliking for emotionally ‘bland’ music. These findings were consistent with those that evidenced a preference amongst high P individuals for hard-rock music (e.g. Rawlings et al. 1995), and further reaffirm the relationship between the constructs of sensation-seeking and P.

Seen in this light, musical enjoyment is best conceptualised as a higher-order cognition that is only loosely related to immediate emotional reactions.
References


with measures of the five-factor model of personality. *Personality and Individual Differences, 6*(5), 587-597.


and Individual Differences, 13(7), 757-785.


Appendix 1

The Pilot Study
**Details of the pilot study**

The pilot study involved the testing of ten friends and colleagues of the experimenter. These included 5 males and 5 females, of mean age 28.5 (sd = 14.58). These volunteers were asked to listen to a series of 48 sound and 48 music clips through headphones, and rate each on the 9-point SAM scales of valence and arousal included within Bradley and Lang’s (1999) IADS Package.

Based on the average valence and arousal ratings across all volunteers, sound and musical stimuli were selected for each of the six *a priori* valence/arousal categories used in the current study. Valence ratings between 1-4 were assigned to a ‘low’ valence category, 4-6 to a ‘neutral’ category, and 6-9 to a ‘high’ category. Arousal ratings between 1-5 (inclusive) were assigned to a ‘low’ category, and 5-9 to a ‘high’ category.

The stimuli that were chosen for the present experiment are tabled on the following page. Due to a computer malfunction, the titles and composers of each of the musical pieces were unfortunately lost. (Interested parties should contact Tim Bednall, Dr David Rawlings or Dr Nick Allen for a copy of the stimuli in .WAV format.) The style of music, and whether each excerpt contained vocals is instead listed.

The list order is the same as the order of presentation within the experiment. The alternate order positions (used with one half of the participants), is listed in the “Order 2” column of the table.
### Table A1. Stimuli chosen for the present experiment

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<tr>
<th>Example</th>
<th>Stimulus</th>
<th>Description</th>
<th>Vocals?</th>
<th>Arousal Rating</th>
<th>Valence Rating (Assigned Category)</th>
<th>Order Position</th>
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<td>N/a</td>
<td>N/A</td>
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<td></td>
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<tr>
<td>2</td>
<td>Electricity</td>
<td>N/A</td>
<td>N/a</td>
<td>N/A</td>
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</tr>
<tr>
<td>3</td>
<td>Soft Rock</td>
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<td>N/A</td>
<td>N/A</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Pop</td>
<td>Yes</td>
<td>N/A</td>
<td>N/A</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

| Sound | 1 | Female Laughter | N/A | 6.9 (High) | 7.5 (High) | 17 |
|       | 2 | Woman screaming | N/A | 8.4 (High) | 2.4 (Low) | 19 |
|       | 3 | Railway Crossing Bell | N/A | 7.2 (High) | 5.1 (Neutral) | 16 |
|       | 4 | Drinking out of a bottle | N/A | 4.1 (Low) | 6.6 (High) | 7 |
|       | 5 | Toilet flush | N/A | 3.4 (Low) | 4.6 (Neutral) | 14 |
|       | 6 | Mosquito Buzz | N/A | 4.9 (Low) | 3.8 (Low) | 22 |
|       | 7 | Heavy Traffic | N/A | 6.9 (High) | 2.7 (Low) | 5 |
|       | 8 | Woman singing in shower | N/A | 4.4 (Low) | 6.7 (High) | 11 |
|       | 9 | Wolf baying | N/A | 5.5 (High) | 4.9 (Neutral) | 21 |
|       | 10 | Blowing nose | N/A | 4.1 (Low) | 3.7 (Low) | 12 |
|       | 11 | Pen scribbling on paper | N/A | 4.7 (Low) | 5.1 (Neutral) | 6 |
|       | 12 | Man and woman making love | N/A | 7.6 (High) | 7.4 (High) | 10 |
|       | 13 | Electrical Feedback | N/A | 7.8 (High) | 5.2 (Neutral) | 8 |
|       | 14 | Chuckling | N/A | 5.3 (High) | 7.0 (High) | 13 |
|       | 15 | Coughing | N/A | 4.8 (Low) | 2.4 (Low) | 9 |
|       | 16 | Clothing Zipper | N/A | 4.5 (Low) | 4.9 (Neutral) | 20 |
|       | 17 | Car won’t start | N/A | 5.4 (High) | 2.8 (Low) | 15 |
|       | 18 | Birds tweeting | N/A | 2.6 (Low) | 7.1 (High) | 18 |

| Music | 1 | Jazz | Yes | 1.5 (Low) | 4.9 (Neutral) | 6 |
|       | 2 | Soft Rock | Yes | 3.2 (Low) | 3.2 (Low) | 3 |
|       | 3 | Latin | No | 1.7 (Low) | 6.2 (High) | 7 |
|       | 4 | Hard Rock | No | 6.7 (High) | 4.5 (Low) | 15 |
|       | 5 | Techno | No | 8.3 (High) | 6.9 (High) | 8 |
|       | 6 | Techno | No | 6.7 (High) | 5.5 (Neutral) | 16 |
|       | 7 | Instrumental | No | 2.7 (Low) | 3.9 (Low) | 17 |
|       | 8 | Blues | No | 5.4 (High) | 6.3 (High) | 18 |
|       | 9 | Soft Rock | No | 3.1 (Low) | 4.8 (Neutral) | 14 |
|       | 10 | Soft Rock | Yes | 5.5 (High) | 4.9 (Neutral) | 5 |
|       | 11 | Country | Yes | 4.4 (Low) | 6.5 (High) | 13 |
|       | 12 | Hard Techno | Yes | 7.6 (High) | 4.0 (Low) | 1 |
|       | 13 | Easy Listening | No | 3.1 (Low) | 6.6 (High) | 4 |
|       | 14 | R&B | Yes | 2.6 (Low) | 3.9 (Low) | 12 |
|       | 15 | Gothic Rock | Yes | 6.4 (High) | 4.1 (Low) | 10 |
|       | 16 | Classical | Yes | 8.4 (High) | 4.8 (Neutral) | 11 |
|       | 17 | Dance Techno | No | 6.6 (High) | 7.2 (High) | 2 |
|       | 18 | R&B | Yes | 4.6 (Low) | 5.1 (Neutral) | 9 |
Appendix 2

Instruction Sheet for Participants
Instructions for Rating the Sounds

In this study, you will be presented with 36 music and sound samples through the headphones. Some of these are designed to be emotionally evocative, and we would like to find out how they affect you.

Following each sample, you will be asked to rate how the sounds made you feel. You will be asked about three different kinds of feelings: 1) **Happy VS Unhappy**, 2) **Excited VS Calm**, and 3) **In-Control VS Controlled**. You will also be asked: 4) **how familiar are you** with the sound / music, and 5) how much did you **like/enjoy** that sound / music?

When you are asked to make a rating, a figure called SAM (the “Self-Assessment Manikin”) will appear on the television screen ahead of you. You can control SAM’s expression by turning the silver knob on the controller box, and can make a final selection by pushing the red button.

![SAM - The Self Assessment Manikin](image)

Read the instructions on the following pages, and use SAM and the sliding scales to rate how each audio sample made you feel.
The first scale is the *Happy VS Unhappy* scale, which ranges from a frown to a smile.

At the right extreme of the scale are emotions that are highly positive (e.g. pleasure, satisfaction, contentedness, hope). If you feel completely *happy* while listening to the sound/music presentation, you can indicate this by turning the knob on the controller completely to the right, and selecting the figure by pressing on the red button.

The other end of the scale reflects emotions that are highly negative (e.g. annoyance, dissatisfaction, melancholy, despair, anger). If you feel completely *unhappy* while listening to the sound/music presentation, you can indicate this by using the controller to select the figure with the unhappiest expression.

If, in your judgement, your feelings of happiness or unhappiness do not reflect the extremes of this scale, use the computer to select a figure with a moderately happy/unhappy expression.

If you feel completely neutral (i.e. neither happy nor sad) then you can use the computer to select the (middle) figure with the neutral expression.

**VERY IMPORTANT -** When rating music, remember that you are NOT rating how much you ENJOY or LIKE each piece on this scale. Do not rate the clips according to your like/dislike of particular musical styles, or on the basis of the musicians’ talent. **The purpose of this scale is to measure how each of the presentations made you feel emotionally (i.e. happy vs. sad).**

It may be possible to hear a song, which is brimming with positive emotions that you do not enjoy listening to, or alternatively, a sad piece that you find quite enjoyable.
The second scale is the *Excited VS Calm* scale – which ranges from very excited to very calm

At the right extreme of the scale are feelings of intense stimulation (e.g. excitement, frenzy, jitteriness, hyperactivity, arousal). If you feel completely *aroused* while listening to the sound/music presentation, you can indicate this by using the controller to select the figure with the greatest arousal.

The other extreme of the scale reflects strong feelings of calm (e.g. relaxation, sluggishness, sleepiness, dullness). If you feel completely *calm* while listening to the sound/music presentations, you can indicate this by using the computer to select the figure that has the calmest expression.

If, in your judgement, your feelings of arousal or calmness do not reflect the extremes of this scale, you can use the computer to select a figure with a moderately aroused/calm expression.

If you feel completely neutral (i.e. neither aroused nor calm) then you can use the computer to select the (middle) figure with the neutral expression.

---

**VERY IMPORTANT -** When rating music, remember that you are NOT rating how much you ENJOY or LIKE each piece on this scale. Do not rate the clips according to your like/dislike of particular musical styles, or on the basis of the musicians’ talent. **The purpose of this scale is to measure how energetic/calm each of the presentations made you feel.**
The third scale is the *In-Control VS Controlled* scale – which ranges from very excited to very calm

At the right extreme of this scale are feelings of extreme control (e.g. dominance, assertiveness, authority, boldness, importance and autonomy). If you feel completely *in-control* while listening to the sound/music presentation, you can indicate this by using the controller to select the biggest figure (with the greatest look of dominance).

The other extreme of the scale reflects strong feelings of being controlled (e.g. being influenced, overwhelmed, guided, awed or submissive). If you feel completely *controlled* while listening to the sound/music presentations, you can indicate this by using the computer to select the smallest figure (with the most timid expression).

If, in your judgement, your feelings of control do not reflect the extremes of this scale, you can use the computer to select a figure with a moderately dominant/controlled expression.

If you feel completely neutral (i.e. neither dominant nor controlled) then you can use the computer to select the (middle) figure with the neutral expression.
The fourth scale is the *Familiarity* scale – which ranges from highly familiar to not at all familiar

(Note that this rating will be plotted on a sliding scale – SAM will not appear for this section.)

<table>
<thead>
<tr>
<th>Not at all familiar</th>
<th>Highly familiar</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

The right extreme of the scale represents great familiarity with the sound/music clip. In the sound condition, if the sound is familiar to you (e.g. you can easily recognise it, or hear it often), use the computer to select a point at this end of the scale. In the musical condition, if the clip is highly recognisable to you (e.g. you can name the song/artist, if you hear it often on the radio, or own the album), use the computer to select a point at this end of the scale.

The opposite end of the scale represents a lack of familiarity with the sound/music clip. In the sound condition, if the sound is unfamiliar to you (e.g. you have difficulty recognising it, or hear it infrequently), use the computer to select a point at this end of the scale. In the musical condition, if the clip is highly unfamiliar to you (e.g. you cannot name the song/artist, or you have never heard it before), use the computer to select a point at this end of the scale.

If, in your judgement, you feel you *might* have heard the presentation (but you are not completely sure), you can use the computer to select a point that is not at either extreme of the scale. The point you choose should reflect your degree of certainty that you have/have not heard the song or the type of sound before.

If you feel completely unsure about whether or not you are familiar with the presentation, then you can use the computer to select the mid-point of the scale.

**VERY IMPORTANT - When rating music, try not to rate each piece based on your familiarity with its musical style. **RATHER, THE PURPOSE OF THIS SCALE IS TO MEASURE HOW FAMILIAR YOU ARE WITH EACH EXCERPT SPECIFICALLY.**

Again, this scale should also not be used to reflect your enjoyment or like of each musical excerpt.
The final scale is the *Enjoyment* scale – which ranges from highly enjoyable to not at all enjoyable

(Note that this rating will be plotted on a sliding scale – SAM will not appear for this section.)

Dislike it very much

Like it very much

1 2 3 4 5 6 7 8 9

The right extreme of the scale represents great enjoyment at listening to the music/sound clips. If you experience great enjoyment while listening to the presentations (e.g. like, interest, amusement, entertainment, or connection to the music/sound), use the computer to select a point at the end of this scale.

The opposite extreme of this scale represents a great displeasure at listening to the sound/music clip. If you experience great displeasure while listening to the presentations (e.g. dislike, disinterest, boredom, loathing, alienation), use the computer to select a point at this end of the scale.

If, in your judgement, you feel that your enjoyment/displeasure does not reflect either extreme of the scale, you can use the computer to select a moderate point away from the ends of the scale.

If you feel neither enjoyment or displeasure (i.e. completely neutral) with the presentation, then you can use the computer to select the mid-point of the scale.
Appendix 3

Debriefing Form
Debriefing Information for Student Participants

The study you participated in today aims to explore the issue of how it is possible for a person to enjoy the experience of listening to music that is perceived as unpleasant (e.g. sad, frightening, angry). Three theories have been formulated to explain this phenomenon, and we were attempting to find support for one of these. These theories include: 1) a cognitivist explanation (which argues that emotions are perceived within music but not experienced), 2) an emotivist explanation (which argues that people experience a special set of ‘aesthetic’ emotions when listening to music that are qualitatively different to everyday emotions), and 3) an associative network explanation (which argues that listening to music stimulates ‘real’ emotions, but inhibits displeasure centres within the brain).

In order to substantiate one of these theories, the study will look for differences in the way people respond emotionally to presentations of music versus sound. These comparisons will include the data obtained from the rating scales, as well as the physiological measurements taken during the presentations.

The second part of this experiment aims to examine the potential moderating effect of the personality characteristic ‘Tough-mindedness’ (also called ‘Psychoticism’) on the enjoyment of unpleasant music. Previous research has suggested that people with high ‘Tough-mindedness’ possess a heightened threshold for unpleasant stimuli, and a preference for ‘hard rock’ music and harsh chords.

For this experiment, we recruited participants from the previous screening process who were rated either high or low on this personality dimension, and assigned these individuals to separate groups. We intend to compare the emotional reactions of both groups, in an attempt to identify effects associated with high ‘Tough-mindedness’ on the enjoyment of unpleasant music. It is also our intention to search for general patterns of musical preference for high ‘Tough-mindedness’ individuals, based on the emotional content of music.

You were selected for the [low / high] ‘Tough-mindedness’ group. Neither low nor high ‘Tough-mindedness’ is abnormal, and neither implies a personal deficiency in intelligence, personality or morality. If you would like more information about the concept of Tough-mindedness / Psychoticism, please refer to the Personality section of your first-year textbook. Another excellent reference is the book “Personality Traits”, by Gerald Matthews and Ian J. Deary (the book you will study if you do 512-223 next year).

A summary of the general findings of this study will be made available once the data has been collected and analysed. These will appear at the URL http://www.student.unimelb.edu.au/~tbednall/exp.html. It is estimated that the results will be published here around November. If you have questions in the meantime regarding this study, please do not hesitate to contact one of the investigators (see the contact details on the information sheet you were given at the beginning of the session.)

Thank you for your participation in this study – it is greatly appreciated.

David Rawlings      Nick Allen      Tim Bednall
Appendix 4

Mean self-report ratings and physiology difference scores for each a priori valence/arousal category, in sound and music conditions.
Table A2.  
Mean self-report ratings and physiology difference scores for each a priori valence/arousal category, in sound and music conditions.

<table>
<thead>
<tr>
<th>Rating Measure</th>
<th>Low Arousal</th>
<th>High Arousal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unpleasant</td>
<td>Neutral</td>
</tr>
<tr>
<td></td>
<td>M  SD</td>
<td>M  SD</td>
</tr>
<tr>
<td><strong>Sound Condition</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self Report</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valence</td>
<td>8.0 1.9</td>
<td>9.4 2.0</td>
</tr>
<tr>
<td>Arousal</td>
<td>11.8 2.3</td>
<td>10.1 2.2</td>
</tr>
<tr>
<td>Physiology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrugator EMG</td>
<td>0.6 10.3</td>
<td>0.5 9.3</td>
</tr>
<tr>
<td>Zygomatic EMG</td>
<td>1.9 7.1</td>
<td>-2.2 15.8</td>
</tr>
<tr>
<td>Startle Reflex (×100)</td>
<td>17.0 45.5</td>
<td>-3.5 53.2</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>-1.6 2.9</td>
<td>-2.8 4.5</td>
</tr>
<tr>
<td>Skin Resistance</td>
<td>-9.3 45.8</td>
<td>-14.0 45.9</td>
</tr>
<tr>
<td><strong>Music Condition</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self Report</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valence</td>
<td>9.6 2.5</td>
<td>11.2 2.0</td>
</tr>
<tr>
<td>Arousal</td>
<td>6.6 2.3</td>
<td>7.2 2.6</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>12.2 3.0</td>
<td>12.9 2.7</td>
</tr>
<tr>
<td>Physiology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrugator EMG</td>
<td>1.7 8.7</td>
<td>0.4 8.3</td>
</tr>
<tr>
<td>Zygomatic EMG</td>
<td>-0.9 11.1</td>
<td>0.7 14.8</td>
</tr>
<tr>
<td>Startle Reflex (×100)</td>
<td>23.3 53.5</td>
<td>15.1 58.1</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>-1.0 4.0</td>
<td>-1.1 3.0</td>
</tr>
<tr>
<td>Skin Resistance</td>
<td>-3.5 36.6</td>
<td>-5.1 39.6</td>
</tr>
</tbody>
</table>

*Note.* Where transformations were made, statistics in this table are based on the original values of each variable (excluding the standardised startle reflex data).
Appendix 5

Mean Difference Scores (Self-Report and Physiology) between High-P and Low-P Participants for Sound Presentations
Table A3. 
Mean Difference Scores (Self-Report and Physiology) between High-P and Low-P Participants for Sound Presentations

<table>
<thead>
<tr>
<th>Sound Condition</th>
<th>Low Arousal</th>
<th>High Arousal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unpleasant</td>
<td>Neutral</td>
</tr>
<tr>
<td><strong>Self Report</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valence</td>
<td>.1833</td>
<td>.1500</td>
</tr>
<tr>
<td></td>
<td>(.5923)</td>
<td>(.6287)</td>
</tr>
<tr>
<td>Arousal</td>
<td>.4833</td>
<td>-.5667</td>
</tr>
<tr>
<td></td>
<td>(.723)</td>
<td>(.6867)</td>
</tr>
<tr>
<td><strong>Physiology</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrugator EMG</td>
<td>2.555</td>
<td>-2.2740</td>
</tr>
<tr>
<td></td>
<td>(3.274)</td>
<td>(2.9432)</td>
</tr>
<tr>
<td>Zygomatic EMG</td>
<td>-.9401</td>
<td>4.8090</td>
</tr>
<tr>
<td></td>
<td>(2.267)</td>
<td>(4.9974)</td>
</tr>
<tr>
<td>Startle Reflex</td>
<td>0.052554</td>
<td>0.17075*</td>
</tr>
<tr>
<td></td>
<td>(0.079953)</td>
<td>(0.079356)</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>-.9347</td>
<td>-.6627</td>
</tr>
<tr>
<td></td>
<td>(-2.847)</td>
<td>(1.4426)</td>
</tr>
<tr>
<td>Skin Resistance</td>
<td>.1456</td>
<td>19.0293</td>
</tr>
</tbody>
</table>

Music Condition

| **Self Report** |            |         |          |            |         |          |
| Valence         | -1.2333    | -1.5167*| -.7333   | -.2667     | -.8500  | -1.1500(*)|
|                 | (.7750)    | (.5965) | (.6678)  | (.8357)    | (.6613) | (.6377)   |
| Arousal         | 1.1500     | .6833   | 1.7167*  | -.1667     | .1167   | -.4667    |
|                 | (.7226)    | (.8210) | (.7042)  | (.7771)    | (.7461) | (.7330)   |
| Familiarity     | -.1833     | .0500   | .0666    | 1.0167     | -.1500  | -1.1000   |
|                 | (1.2440)   | (1.1038)| (1.1447) | (1.3105)   | (.9931) | (1.2197)  |
| Enjoyment       | -.8833     | -2.6500***| -1.6167(*)| 2.5667*     | .3500   | -.6667    |
|                 | (.9603)    | (.7512) | (.9099)  | (1.1755)   | (.6184) | (.9539)   |
| Enjoyment       | -0.8196    | -2.6647***| -1.6373(*)| 2.1491(*)   | .3976   | -0.4304   |
| Residuals*      | (0.8590)   | (0.6756)| (0.8370) | (1.0673)   | (0.5313)| (0.9201)  |
| **Physiology** |            |         |          |            |         |          |
| Corrugator EMG  | -4.3058    | 4.8586(*)| -1.4717  | 2.1933     | .5469   | 1.1339    |
|                 | (2.6950)   | (2.5552)| (2.4668) | (2.4712)   | (1.9275)| (2.9832)  |
| Zygomatic EMG   | -6.4711(*) | -3.9106 | -5.3687  | -5.4427    | -.5916  | 2.9057    |
|                 | (3.4112)   | (4.6846)| (4.4785) | (3.3770)   | (2.9339)| (3.9542)  |
| Startle Reflex  | 0.063046   | 0.015778| -0.01087 | -0.02574   | 0.051306| 0.027333  |
|                 | (0.10087)  | (0.088132)| (0.088019)| (0.093647)| (0.08859)| (0.091169)|
| Heart Rate      | .5582      | -.7075  | .0460    | 1.3695     | -1.0813 | -.2799    |
|                 | (1.3147)   | (0.9725)| (0.8224) | (1.0938)   | (.8750) | (1.0106)  |
|                 | (11.1760)  | (12.5841)| (18.1729)| (15.3133) | (11.7754)| (17.5839)|

Note: Standard errors of difference scores are indicated in parentheses. Difference scores reflect (P+) - (P-) (untransformed) mean scores. Comparisons were made using independent-samples t-tests (two tailed).

*Refers to the residual values generated by regression analyses predicting enjoyment from familiarity.

(*) p < .10, * p < .05, ** p < .01, *** p < .001
Appendix 6

Mean self-report and physiology difference scores for music, in empirical enjoyment categories
Table A4.
Mean self-report and physiology difference scores for music, in empirical enjoyment categories

<table>
<thead>
<tr>
<th></th>
<th>Low Enjoyment</th>
<th>Medium Enjoyment</th>
<th>High Enjoyment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Self Report</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valence</td>
<td>10.2</td>
<td>10.7</td>
<td>11.7</td>
</tr>
<tr>
<td></td>
<td>1.8</td>
<td>1.9</td>
<td>1.6</td>
</tr>
<tr>
<td>Arousal</td>
<td>12.8</td>
<td>9.0</td>
<td>9.4</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
<td>1.5</td>
<td>1.8</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>9.8</td>
<td>12.1</td>
<td>13.7</td>
</tr>
<tr>
<td></td>
<td>2.7</td>
<td>2.5</td>
<td>2.1</td>
</tr>
<tr>
<td><strong>Physiology</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrugator EMG</td>
<td>0.0</td>
<td>1.7</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>5.1</td>
<td>5.4</td>
<td>5.1</td>
</tr>
<tr>
<td>Zygomatic EMG</td>
<td>2.0</td>
<td>-0.7</td>
<td>1.9</td>
</tr>
<tr>
<td></td>
<td>9.4</td>
<td>8.6</td>
<td>8.2</td>
</tr>
<tr>
<td>Startle Reflex (×100)</td>
<td>-25.0</td>
<td>29.0</td>
<td>-4.1</td>
</tr>
<tr>
<td></td>
<td>34.0</td>
<td>34.6</td>
<td>33.7</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>-1.0</td>
<td>-1.0</td>
<td>-1.3</td>
</tr>
<tr>
<td></td>
<td>2.6</td>
<td>2.4</td>
<td>1.9</td>
</tr>
<tr>
<td>Skin Resistance</td>
<td>-14.0</td>
<td>-8.8</td>
<td>-14.3</td>
</tr>
<tr>
<td></td>
<td>35.4</td>
<td>43.4</td>
<td>29.7</td>
</tr>
</tbody>
</table>
Appendix 7

Correlations between reported enjoyment and other self-report ratings for each *a priori* music category
Table A5. Correlations between reported enjoyment and other self-report ratings for each *a priori* music category

<table>
<thead>
<tr>
<th>Music Category</th>
<th>Familiarity</th>
<th>Valence</th>
<th>Arousal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Valence / Low Arousal</td>
<td>.445**</td>
<td>.174</td>
<td>-.175</td>
</tr>
<tr>
<td>Low Valence / High Arousal</td>
<td>.435**</td>
<td>.412**</td>
<td>.338*</td>
</tr>
<tr>
<td>Neutral Valence / Low Arousal</td>
<td>.376*</td>
<td>.406**</td>
<td>-.200</td>
</tr>
<tr>
<td>Neutral Valence / High Arousal</td>
<td>.507**</td>
<td>.105</td>
<td>.410**</td>
</tr>
<tr>
<td>High Valence / Low Arousal</td>
<td>.374*</td>
<td>.380*</td>
<td>-.163</td>
</tr>
<tr>
<td>High Valence / High Arousal</td>
<td>.276(*)</td>
<td>.673**</td>
<td>.312</td>
</tr>
</tbody>
</table>

*Note.* (*) p < .10, * p < .05, ** p < .01