



Characteristics of music and their influence upon emotion

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### **ABSTRACT**

Music holds inherent properties capable of influencing our emotional state. Characteristics of music such as mode and tempo are thought to influence emotional reactions and allow us to modulate our own emotional state through music listening. In an attempt to distinguish the effects of changing musical characteristics a replication of Van der Zwaag et al's (2011) study was performed with adjustments. 20 participants listened to four musical tracks of which the characteristics of tempo and mode had been altered. Participants rated experienced arousal, valence and tension, whilst physiological measures of heart rate and skin conductance were recorded. Major mode music was shown to increase participant's ratings of subjective positive valence and increase levels of skin conductance whilst reducing heart rate in relation to minor mode music. Increases in the tempo of music were found to raise participant's subjective arousal scores. Whilst results from this study confirm current literature some results do show discrepancies with Van der Zwaag et al's findings, theories for these differences are explored. Overall results show that tempo and mode do have emotional modulating characteristics and findings from this study increase our understanding of emotional influence through music. This study raises intriguing possibilities for future research and lends support to the use of music as therapy.

<b>KEY WORDS:</b>	<b>MUSIC</b>	<b>EMOTION</b>	<b>MUSIC THERAPY</b>	<b>ECG</b>
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## Introduction

This dissertation investigates the phenomena in which musical characteristics can influence our emotional state. Emotion modulation is believed to be one of music's most important features (Saarikallio & Erkkilä, 2007) and has many important implications for both treatment of mental disorders and for our everyday lives.

For thousands of years people have turned to the arts in order to evoke or influence emotions. Plato famously said that the reason poetry has such a bad moral influence upon people is because it appeals to emotion the highest part of the soul, rather than reason (Robinson, 2005). Whilst the usefulness of philosophical statements can be debated, many people still listen to music in attempts to induce relaxed or happy emotional states (Juslin & Sloboda, 2010; Kenealy, 1988; Thayer et al, 1994 ). Music has also been demonstrated to have a positive effect on performance in both physical and mental situations (Lane et al, 2011; Rauscher et al, 1995; Colwell, 1994); therefore it is not difficult to believe music's use in mood and emotion modulation. Research shows the direct link between music listening and its influence upon emotions (Menon & Levitin, 2005; Van Der Zwaag et al, 2011). Juslin & Laukka (2010) note that emotion is strongly related to peoples primary motives for listening to music.

## Music and therapy

Emotions can control the way in which we perceive ourselves and the world around us. In positive states of mind we receive many benefits including greater motivation and increased cognitive abilities such as memory (Lee & Sternthal, 1999; Isen, 1993). When our emotions can provide such benefits and music can influence these emotions, if we utilise knowledge relating to music's influence it is possible to use music as a therapy and a tool to increase performance in many areas. From knowledge of music's benefits, a form of therapy has been created known as 'Music Therapy' (Bunt & Pavlicevic, 2001). This therapy has been used to assist cancer patients and research has shown an increase in patient's well-being and relaxation. In addition to this, data has shown a link between the positive emotions created by this therapy and benefits in cancer patient's immune system (Burns, 2001). These staggering findings from real world applications show how emotion evoked by music has important consequences for people's wellbeing.

## Mechanisms of music's influence

As it has been shown how music can influence emotion, it is beneficial to understand how this occurs. Juslin & Västfjäll (2008) suggest six underlying mechanisms that can explain how music influences emotion. These mechanisms include; brain stem reflexes (emotion induced by a musical characteristic which could indicate an important or urgent event), evaluative conditioning (emotion induced due to music being repeatedly associated with a positive or negative stimuli), emotional contagion (emotion induced due to listener perceiving an emotion portrayed in the music and mimicking it), visual imagery (emotions induced due to the listener conjuring up visual images), episodic memory (emotion induced due to the music evoking a memory of a particular event in the listeners life), and finally musical expectancy

(emotion induced due to the musical piece either violating or confirming the listeners expectation) (Juslin & Västfjäll, 2008). Thompson & Coltheart (2008) expand upon Juslin & Västfjäll's theory suggesting that these six mechanisms can each fall into one of two categories, either signal detection or amplification. The signal detection category is detailed as unmediated sources of emotion as they influence emotion directly by detecting emotive signals in music. The mechanisms in this category include; brain stem reflexes, expectancy and evaluative conditioning. Mechanisms in the amplification category are said to act in conjunction with signal detection mechanisms in order to induce emotion, the mechanisms in this category include visual imagery, episodic memory and emotional contagion (Thompson & Coltheart, 2008).

The mechanism of emotional contagion is the phenomena of an emotion being induced due to a listener perceiving an emotion portrayed in music and their own emotional state mimicking it. This is shown in other literature, where an explanation given for music's influence on emotion is that music creates an awareness of our own emotional state (Krumhansl, 1997; Baumgartner et al, 2006). However Scheier & Carver (1977) suggests that the awareness of our own emotional state is derived from self focused attention, Silvia (2002) also suggests that during self-focused attention the intensity of emotions we experience is amplified. The implications of this are in opposition to theories suggesting that music influences emotion, as if we are listening to music our attention will not be on our self. Despite music drawing us away from self-focused attention music is often experienced in the background without full attention, and studies still show music's influence on emotion when presented in the background. An example of background music's influence involves Van Der Zwaag et al's (2011) study, where music was presented alongside an office task as background noise instead of the participant's primary focus. This study shows how even if music is not subject to full attention, it can still influence people. Van der Zwaag et al's (2011) study provides great knowledge for the influence of music on emotions and will be described in detail later. Studies have also investigated music's influence upon emotion with the musical piece being the main focus (Juslin et al, 2009). The positive results from such studies suggest that it does not matter if music is presented in the foreground or background; results still indicate an effect on participant's emotional state despite being contrary to Scheier & Carver's (1977) theory.

Juslin & Sloboda (2010) suggest that music evokes emotions in two ways, through its structural properties and through an individual's associations with the music. When listening to music our reactions can be influenced by a memory, or associations with the song; this is prominent in much literature (Schulkind, Hennis & Rubin, 1999; Jäncke, 2008). The idea of emotions being influenced by associations and memories is in line with the episodic memory and evaluative conditioning mechanisms suggested by Juslin & Västfjäll (2008). However, if our reaction to music was fully influenced by associations then the emotions experienced by individuals listening to a track would vary greatly (Krumhansl, 2002). As it stands this is not the case, a musical track will influence many individuals in much the same way. Krumhansl suggests that musical sounds in themselves may have emotional meaning, Evidence has shown that between individuals and even cross cultures certain music will influence the same emotional responses (Hevner, 1936; Balkwill &

Thompson, 1999). If individuals are being influenced by a track in the same way, then it is possible that some feature of that track is causing this reaction.

The mode of music is one such cross-cultural feature; major mode music is often associated with happier responses whilst minor mode is associated with sadder responses (Webster & Weir, 2005). Gregory, Worrall & Sarge (1996) suggest that our response to the musical characteristic of mode is learned. Gregory, Worrall & Sarge (1996) found that when played music in either the major or minor mode, children aged 7 to 8 could accurately match happy and sad emotions to the corresponding mode as an adult would. Children aged 3 to 4 however could not accurately place the emotion with the musical mode. This finding does indeed suggest that our responses to music's mode develop at a young age.

### **Musical characteristics and their emotional responses**

There are other musical characteristics which have been shown to have a relationship with an individual's emotional responses including surprise, tempo and percussiveness. If an individual's expectation of a track is violated then surprise may be induced, if this continues an increase in arousal can occur (Steinbeis et al, 2006). The texture of music has also been shown to influence emotional responses. For example complex harmonies have been linked with low valence, whilst simple harmonies have been linked with higher valence (Webster & Weir, 2005). The concept of valence relates to the positivity or negativity of emotion, for example positive valence emotions can include states such as happiness and excitement, whilst negative valence emotions include states such as fear and anger. Out of all musical characteristics tempo and mode are the most studied. It is believed that when influencing emotions the tempo of music is the most important characteristic and influences a wide range of emotions (Hevner, 1937). However there is some contradicting evidence, Kamenetsky et al (1997) presents the finding that when participants were played music varying in dynamics (mode) and tempo, variations in dynamics brought about higher ratings of emotional expressiveness whilst variations in tempo had no effect. Whilst this evidence is to the contrary this study relies upon self report measures, which are known to have many problems when dealing with complex concepts such as emotion (Spatz & Kardas, 2007; Boyle, 1985). For the aspect of musical mode, major mode music can be associated with high valence levels and happiness, whilst minor mode music is known to be associated with lower or negative valence and sad emotions (Webster & Weir, 2005; Van Der Zwaag et al, 2011; Hevner, 1936). For the tempo aspects of music, slow tempo music is considered low arousal and is often associated with sad low valence emotions. Meanwhile fast tempo music is considered high arousal and is associated with higher valence emotions (Webster & Weir, 2005; Van Der Zwaag et al, 2011). The emotions influenced by a song's tempo have a wide range, emotions such as anger, fear; surprise, happiness and pleasantness are all assumed to be modulated by a song's tempo (Gabrielsson & Lindström, 2010). Whilst tempo is mainly associated with the arousal dimensions of emotion, mode is often associated with the valence dimension.

## Measuring emotion: Physiological measures

When our emotions change certain physiological changes are also observed (Scherer, 2004; Whorwell et al, 1992), these physiological changes are often observed in order to measure an individual's emotional responses. When studying the effects of music induced emotions several different physiological responses have been observed. Changes in respiration rate have been reported (Nyklíček et al, 1997; Gomez & Danuser, 2004) as well as other physiological features such as variations in facial EMG measures (Bradley & Lang, 2000; Lundqvist et al, 2009). Curiously physical strength has also been shown to be affected (Pearce, 1981). Pearce found that listening to sedative music decreased participants grip strength in relation to silence, whilst stimulative music had no effect. When measuring musically induced emotions certain physiological measures show dominance, these features include electro dermal activity (EDA) and heart activity measures.

EDA relates to the ability of the skin to conduct an electrical current and is closely related to arousal (Hugdahl, 1995). At times of high arousal we perspire, which in turn increases the conductivity of the skin making it easier for an electrical current to pass through (Boucsein, 1992). The link between EDA and arousal has many evolutionary benefits. For example increased sweat gland activity in the palms and soles of feet can lead to increased grip and balance, which in turn leads to greater mobility and increased survival in dangerous situations (Edelberg, 1972). EDA can be measured in multiple ways, the most popular being the recording of skin conductance level (SCL) for emotional research. SCL measurement involves the passing of an electric current through the skin and measuring the amount of resistance (Andreassi, 2007). Levels of skin conductance represent activity in the autonomic nervous system and higher values can indicate high arousal emotions such as happiness and fear (Khalfa et al, 2002; Boucsein, 1992). The autonomic nervous system is a regulator of many important bodily functions such as digestion, body temperature and blood pressure as well as perspiration relating to EDA (Andreassi, 2007).

Measures of heart activity are often used when investigating musically induced emotions (Iwanaga et al, 2005; Riganello et al, 2010; Möckel et al, 1994; Etzel et al, 2005) and a link has been found between heart activity and both the arousal aspect of emotion and the valence aspect (Brosschot & Thayer, 2003; Palomba et al, 1997; Van Der Zwaag et al, 2011). Cacioppo et al (2000) found that high positive valences experienced during happiness or peacefulness was linked to higher scores of time domain heart rate variance. Heart rate variability relates to the phenomena of alterations in the intervals between heartbeats, and values can be obtained through a standard electrocardiographic (ECG) recording (Malik, 1996; Berntson et al, 1997). Heart rate variation has been found to increase during sad, fearful and happy music along with a decrease in heart rate (Krumhansl, 1997), increases in other measures of heart rate variation have been found to correlate with individuals experience of music therapy (Chiu, 2003). Heart activity also relates closely to changes in the sympathetic nervous system (Pomeranz et al, 1985). When an individual experiences negative valence emotions such as fear or anger a reaction can be observed in the sympathetic nervous system. This activation of the sympathetic nervous system can increase heart rate, increase blood pressure and cause perspiration. During states of higher valence the parasympathetic nervous system

can be said to be dominant. The parasympathetic nervous system is primarily associated with rest, repair and enjoyment and can be found to be dominant during eating, sleeping and sexual activity. The outcome of this dominance can include decreased heart rate and peristalsis in the intestines (Andreassi, 2007) relating directly to influences upon heart activity.

Based upon current physiological knowledge we can assume that skin conductance is directly related to arousal due to its relation to the autonomic nervous system which can indicate the experience of high arousal emotions (Khalifa et al, 2002; Boucsein, 1992). We can also assume that heart rate is related to the valence dimension of musically induced emotions as well as arousal due to the multitude of studies linking it with these aspects (Brosschot & Thayer, 2003; Palomba et al, 1997; Van Der Zwaag et al, 2011; Cacioppo et al, 2000).

### **Previous research and its limitations**

Van Der Zwaag et al (2011) performed a study investigating the emotional effect of different musical characteristics. Participants were asked to listen to 16 pop and 16 rock songs whilst carrying out an office task, whilst doing this participants skin conductance and cardiovascular responses were recorded. In addition to physiological responses participants were also asked to rate experienced arousal, tension and valence. The songs selected for this study were specifically chosen for the musical characteristics they possess, these characteristics involved different variations of tempo, mode and percussiveness. Van Der Zwaag et al found that more arousal was reported during minor mode conditions, and that increases in tempo lead to an increase in arousal and tension with a decrease in heart rate variability. It was also found that the level and frequency of skin conductance responses increased with percussiveness. This study is a prime example of research into the emotional impacts of musical characteristics and was undertaken to investigate these effects in an ecologically valid setting; however this study presents a few limitations which the current study will attempt to address. Firstly the songs presented were played in the background, with the office task being the participant's main focus. Whilst this method does improve ecological validity as individuals tend to listen to music as background noise, however with music in the background we cannot be certain that it is the music affecting participants emotions. Despite this research does still show that music can have an effect upon us even if it is presented in the background (Cockerton et al, 1997). An additional problem with this study is that the songs selected for use are all popular music that participants will have most likely heard before. This is a problem as participants could associate memories with these songs, which could influence their emotional reaction. This potential emotional reaction could be explained by the mechanics of evaluative conditioning and episodic memory as suggested by Juslin & Västfjäll (2008). Additionally for each condition every song was completely different; therefore differences in the structure of harmonies could not be accounted for and could cause some confounding emotional reactions (Webster & Weir, 2005). Additionally this difference in songs could present other confounding characteristics; the mechanic of musical expectancy shows us how violations in our expectation of the music can cause emotional reactions (Juslin & Västfjäll, 2008). The number of expectancy violations in the songs used by Van Der Zwaag et al (2011) could differ greatly and cause one song to cause a much bigger reaction than the others due to this characteristic alone. The present

study will be a replication of Van der Zwaag et al's (2011) study, however the limitations described above will be addressed whilst maintaining a similar methodology. The measures and variables used by Van Der Zwaag et al (2011) are ideal for this area of research; however changes will be made to the selection of music in order to fully assess the effects of individual characteristics. Additionally in the present study the aim is to investigate the same effects but with music as the participants main focus.

In this study the emotional responses of participants will be investigated when faced with the changing musical characteristics of mode and tempo. In order to measure these emotional changes participants physiological responses of heart rate and skin conductance will be recorded, in addition to this participant's will supply a self-rate subjective measure of arousal, tension and valence. In this study I aim to investigate any interactions between the changing of musical characteristics on the emotional responses of participants. Based upon previous research I hypothesize that increases in tempo will return higher self rate arousal scores and higher levels of skin conductance. Additionally Major mode music should produce higher scores for experienced valence and with that higher heart rate's.

## **Method**

### **Design**

This study utilised an experimental approach to investigating musically induced emotions and took place in a laboratory setting. A repeated measures design was employed where in total 20 participants took part in four different conditions relating to the mix of musical characteristics available (Major mode fast tempo, major mode slow tempo, minor mode fast tempo and minor mode slow tempo), the order in which these conditions were presented was counter balanced in order to suppress any order effects. The two independent variables used in this study involved the modification of musical characteristics; these were mode (major/minor) and tempo (slow/fast). A total of three dependent variables were measured, these included a mix of physiological measures and a self rate scale. For the physiological measures the participant's skin conductance levels were recorded as well as levels of heart rate variance. The self rate scale asked participants to rate their experienced arousal, tension, positive and negative valence on a 7 point likert scale.

### **Participants**

Twenty participants in total took part in this study, all of whom were students sampled via opportunity from around the University of Northampton Park campus. Whilst age information was not obtained from the population we can assume that most participants fall between the ages of 18 and 30.

## **Materials & Apparatus**

### **Songs**

The music used for this study involved a singular piece of music with certain characteristics modified. The track used for this study was a classical piece by



Ronald Binge entitled Elizabethan Serenade of which participants were unlikely to have heard before. This track was formatted as a MIDI file, this allowed the tempo of the piece to be modified easily without the pitch changing in the process. The musical track was originally at the tempo of 110 BPM; however for the modified conditions the tempo was increased to 140 BPM for the fast condition and was decreased to 80 BPM for the slow condition. This track was presented in both the major and minor mode to participants with the natural mode being minor; each condition was adjusted to be the same length of 1 Minute and 45 seconds using Anvil Studio Midi editing software (Willow Software, 1997). As the track was required to be of equal length for each condition, music had to be cut short for the 80 BPM condition. This was undesirable as faster tempo conditions present much more of the track than slower conditions, however this was unavoidable due to the nature of music and tempo. The music was presented to participants at a normalized volume through Sony MDR-NC6 noise cancelling headphones to ensure participants experienced little other outside noise.

### **Subjective questionnaire**

Participants were required to answer a 4 item questionnaire after they had experienced each condition. This questionnaire assessed participants experienced arousal, tension, positive valence and negative valence during the track. Participant's responses were placed upon a 7 point likert scale for each. This questionnaire is the same one as used in Van Der Zwaag et al's (2011) study.

### **Physiological recordings**

Physiological recordings were obtained using Biopac software and accompanying MP36 hardware. Biopac GSR-18 and EL507 sensors were used to assess cardiovascular and skin conductance responses. For skin conductance two sensors were placed upon the distal phalanges of the participant's middle and index fingers on the non-dominant hand. Cardiovascular measurements involved the placement of sensors on participants left forearm and both right and left ankles. Surgical tape was used to help secure sensors on the fingers and both skin conductance and heart rate was sampled with a frequency of 0-35Hz. Cardiovascular responses were measured in as BPM, which was calculated using Biopac's find rate feature. Skin conductance was measured in micro Siemens and results were calculated for both heart rate and skin conductance by obtaining the mean value of each across the whole time frame of a condition.

### **Procedure**

When participants started the study they were first briefed fully on what the study will involve, an emphasis was placed upon sensor placement as this could potentially cause problems due to the intrusive nature. After participants had been briefed they were asked for consent to take part in the study, this was obtained through signature. After this sensors were attached to participants whilst they were given more in depth information on what would be required. Participants were asked to focus on the music as much as possible and to try and observe their own emotional state. Participants were sat in a comfortable chair and time was allowed for the sensors to settle and for a baseline to be obtained (Boucsein, 1992). The

headphones were given to participants and a test was given to ensure the music was at a comfortable volume. When participants were clear about what was required and were ready the experiment began. Participants were counted down until the music began and then listened to the track in its entirety (1 minute 45 seconds). When this was finished physiological recordings were paused and participants filled out the self rate questionnaire. There was a 2 minute gap between conditions to allow participants reactions to return to a baseline level. This process would continue until all conditions were completed. After all four conditions were carried out participants were informed that the study was over and that they can remove the sensors. Participants were fully debriefed about the purpose of the study and were given information on background research, this information was included on a debrief sheet that the participants could take with them. This debrief sheet also included a unique participant number and contact information for if they wish to withdraw data. Participants were thanked for their participation and were given chance to ask any questions. Overall the experiment took around 20 minutes for each participant.

## Results

The purpose of this study was to investigate if changes in the musical characteristics of mode and tempo have an influence on our emotional reactions. This study included 2 independent variables these were the tempo and mode of a musical track, which were altered for each condition. The dependent variables of this study involve physiological measures of heart rate and skin conductance as well as self-rated experience measures of excitement, positive valence, negative valence and tension. Data obtained was first input into a raw data table this data was then analysed using SPSS 17.0 (SPSS Inc, 2007).

### Physiological Measures

**Table 1**

**Mean scores and standard deviations of physiological measures testing the influence of musical characteristics.**

Experimental Condition	Physiological Measure			
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Major Fast	81.38	5.01	3.53	2.33
Major Slow	81.86	5.68	3.68	2.31
Minor Fast	84.18	6.51	3.99	2.28
Minor Slow	83.99	7.66	3.92	2.29

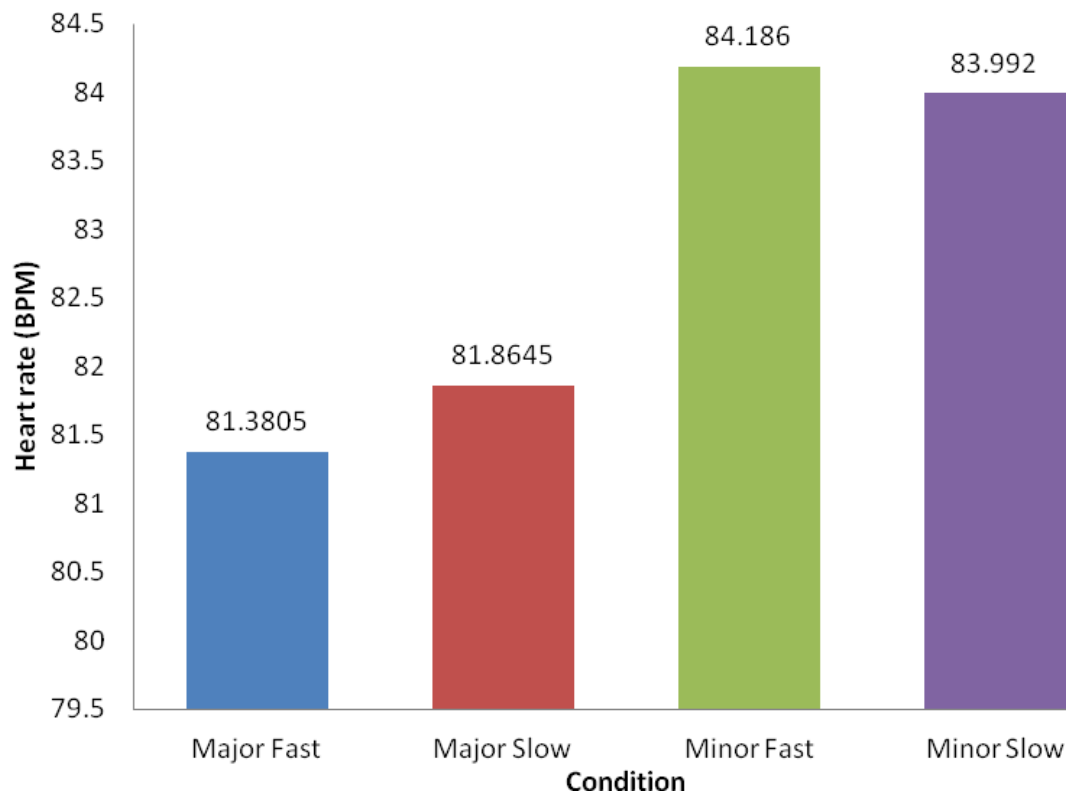
Table 1 shows the mean physiological scores for each experimental condition and the standard deviations. To the eye these scores show very minute differences, however there are some observable effects. For one we can see that the mean heart rate and skin conductance scores for both minor conditions show slightly higher results than their major counterparts. However in order to test the significance of any relationships further analysis was required.

The data collected was analysed using multiple two-way repeated measure ANOVA's as this study utilised a repeated measures design with multiple independent variables, the parametric assumptions of normally distributed data, homogeneity of variances and the absence of extreme scores were also met (Dancey & Reidy, 2007). A separate ANOVA was performed for each individual dependent variable.

### Results for heart rate

Results from the ANOVA used show a significant main effect for heart rate and mode,  $F(1, 19) = 10.62, P = .004$ , the direction of this effect supports the hypothesis that major mode music ( $M = 81.62, SD = 1.14$ ) will produce lower heart rate's than minor mode music ( $M = 84.08, SD = 1.53$ ). There was no significant interaction for mode and tempo on heart rate,  $F(1, 19) = 1.12, P = .303$ , and no significant main effect for tempo,  $F(1, 19) = .037, P = .849$ .

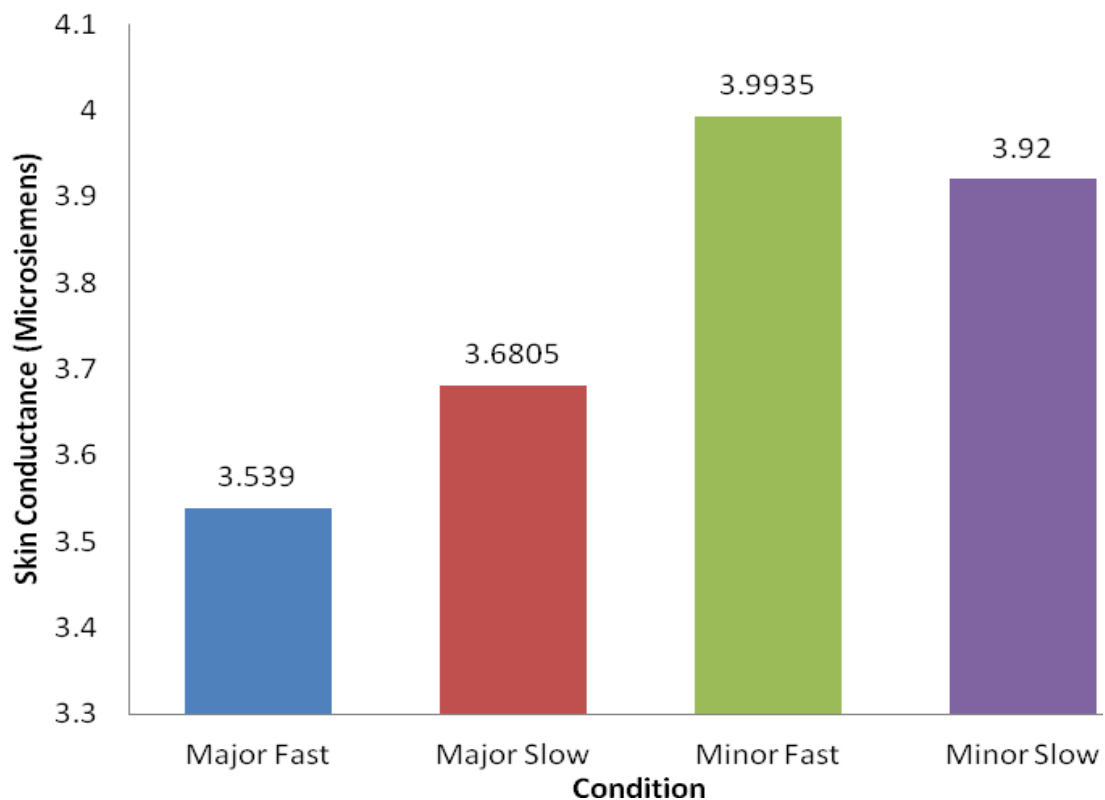
Figure 1 shows the mean heart rates of participants for each individual condition. As the ANOVA suggested there is a significant difference between the major and minor mode music, the largest minor condition score returns a mean of 84.18 whilst the largest major conditions score has a mean of 81.86. The ANOVA results also suggest that there is no significant main effect of tempo upon heart rate,  $F(1, 19) = .037, P = .849$ . This result is expected due to literature indicating that mode is related to cardiovascular effects whilst tempo is related to skin responses (Van Der Zwaag et al, 2011).



**Figure 1: A graph to show the mean heart rates for each condition investigating the effects of changing musical characteristics**

### Results for skin conductance

ANOVA results show a significant main effect between musical mode and skin conductance,  $F(1, 19) = 5.03, P = .037$ . Additionally no significant main effect was found for the effect of tempo upon skin conductance,  $F(1, 19) = .141, P = .711$ . These results were unexpected, it was hypothesised that tempo would increase levels of skin conductance; however this is not the case. Mode was also not expected to have an influence upon skin conductance due to mode being more closely related to cardiovascular responses (Möckel et al, 1994). No significant interaction was found for mode and tempo on skin conductance,  $F(1, 19) = 2.23, P = .152$ . The estimated marginal means for the tempo conditions show that the mean skin conductance score for slow tempo music ( $M = 3.76, SE = .516$ ) is slightly higher than fast tempo music ( $M = 3.80, SE = .508$ ). The results for this were expected to the opposite of this as fast tempo music was hypothesized to increase arousal and therefore produce higher skin conductance scores. The mean skin conductance for each individual condition can be seen in Figure 2.



**Figure 2: A graph to show the mean skin conductance levels for each condition investigating the effects of changing musical characteristics.**

### **Subjective results**

In addition to physiological recordings participants also answered a subjective questionnaire designed to assess each participant's experience of the conditions. Table 2 shows the means and standard errors for each of the subjective measure items. Whilst Table 2 does show that the mean of answers given by participants tend to stick around the middle value of 4, carrying out a two way repeated ANOVA on the data does provide proof of some significant results.

**Table 2**

**The Means and Standard Errors (SE) of the subjective responses to variations in music's tempo and mode.**

		Excitement		Positive valence		Negative valence		Tension	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
Mode	Major	4.32	.137	5.07	.127	2.65	.159	3.32	.182
	Minor	3.92	.127	3.45	.135	4.70	.164	4.40	.124
Tempo	Fast	4.95	.166	4.40	.148	3.57	.122	3.92	.151
	Slow	3.30	.117	4.12	.170	3.775	.172	3.80	.200
Tempo x Mode	Major Fast	5.10	.176	5.45	.185	2.45	.198	3.10	.240
	Major Slow	3.55	.170	4.70	.164	2.85	.221	3.55	.198
	Minor Fast	4.80	.225	3.35	.150	4.70	.147	4.75	.190

### Excitement

A significant effect for tempo was found for the excitement measure,  $F(1, 19) = 51.59, P < .001$ . Fast tempo conditions ( $M = 4.95$ ) supplied significantly higher scores of arousal than slow conditions did ( $M = 3.30$ ). This extremely significant finding does support the hypothesis that an increase in tempo would lead to an increase in subjective arousal. No significant results were found for mode's main effect on excitement,  $F(1, 19) = 3.97, P = .06$ , and there were no significant findings of an interaction of mode and tempo on excitement,  $F(1, 19) = .36, P = .55$ .

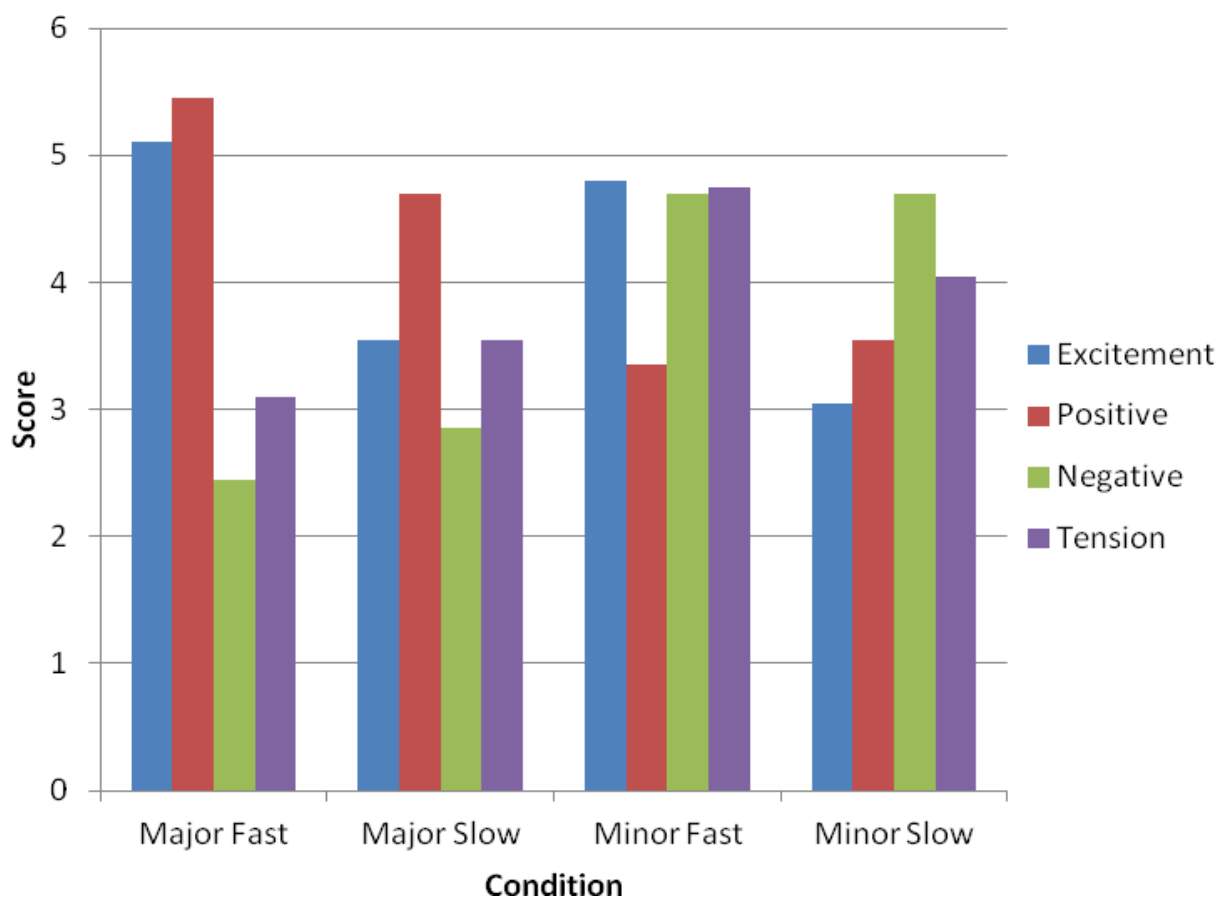
### Positive and negative valence

Significant effects were found for both positive and negative valence measures. Firstly a significant main effect was found for mode's effect upon positive valence scores  $F(1, 19) = 112.27, P < .001$ . For the positive valence measure, major mode conditions ( $M=5.07$ ) returned significantly higher scores than minor conditions ( $M=3.45$ ). This is as expected and in line with my hypothesis that major mode music would produce higher scores of positive valence. There was no significant main effect for tempo,  $F(1, 19) = 1.25, P = .25$ . Additionally a significant interaction effect was found for mode and tempo's influence on excitement,  $F(1, 19) = 16.37, P = .001$ .

For the negative valence measure a significant main effect was found for mode,  $F(1, 19) = 103.36, P < .001$ . Minor mode conditions ( $M=4.70$ ) returned significantly higher scores of negative valence than major mode conditions ( $M=2.65$ ). This finding is in line with my hypothesis that major mode music would produce higher scores of positive valence as negative valence is observed to have the opposite effect. No significant main effect was found for the influence of tempo,  $F(1, 19) = 1.56, P = .226$ , additionally no interaction effect was found for mode and tempo on negative valence,  $F(1, 19) = 1.03, P = .322$ .

## Tension

Finally significant effects were found for the subjective tension scores, mode displayed a significant main effect for tension,  $F(1, 19) = 41.28, P < .001$ . Minor mode music ( $M=4.40$ ) showed higher scores than major mode music ( $M=3.32$ ) for subjective levels of tension. Whilst this measure is included purely for investigation and thus does not have any hypothesis relating to it, this finding does agree with previous early literature (Hevner, 1936). No significant main effect was observed for tempo,  $F(1, 19) = .27, P = .60$ . A tension interaction effect was also found for mode and tempo,  $F(1, 19) = 7.33, P = .014$ . Figure 3 displays all the mean scores of subjective measure for each experimental condition, in graph form it is easy to see the significant differences between some conditions.



**Figure 3: A Graph to show the total means of all subjective ratings for each experimental condition.**

## Physiological and subjective measure correlations

With the mode dimension of music significant results were found for multiple measures. The measures of heart rate, skin conductance, positive valence, negative valence and tension all showed main effects with mode. A Pearson correlation analysis was performed in order to investigate any correlations between these

variables. A correlation was found between participants mean change in heart rates between each musical mode condition and participants mean skin conductance scores,  $r = .565$ ,  $N = 20$ ,  $P = .009$ . A correlation was also found between participants skin conductance scores and heart rate scores,  $r = .849$ ,  $N = 20$ ,  $p < .01$ . These findings suggest that factors influencing heart rate are also influencing skin conductance measures in this study. To further investigate this effect a correlational analysis was performed investigating changes in heart rate and skin conductance and their relationship with the subjective measures of tension, positive valence and negative valence which also showed significant effects with mode. This correlation however did not find any significant relationships between variables.

## Discussion

This study investigated the effects of changing the musical characteristics of mode and tempo on emotions. In an attempt to better understand the musical characteristics involved in emotional influence the methodology of previous research (Van Der Zwaag et al, 2011) was replicated with refinements in order to fully assess music's contribution to our emotional state. Physiological measures and subjective ratings used to assess participant's reactions returned several interesting results relating to the effect of altering different musical characteristics. Significant relationships were found for the effect of mode on heart rate and skin conductance, the effect of tempo on subjective arousal and the effect of mode on subjective valence and tension ratings. Interactions were also found for the effect of mode and tempo on positive valence and tension. In addition to these relationships a correlation between participant's skin conductance and heart rate results was found. Some of these results contribute proof to the hypotheses, however some results provide falsifying evidence, this contrary evidence will be addressed.

It was hypothesised that an increase in music's tempo would lead to higher subjective arousal scores and higher skin conductance levels. This hypothesis is correct in that that subjective excitement scores did show a significant relationship with increases in the tempo of music. However skin conductance results do not match the hypothesised effect. Skin conductance scores showed no significant relationship with the tempo of music, instead mode showed a significant relationship with skin conductance scores. The results for the subjective measure of excitement are in line with other literature (Hevner, 1937; Mattila & Wirtz, 2001) in that levels of excitement were shown to increase along with increases in the music's tempo. However literature shows that as tempo or excitement increases, so should skin conductance (Khalifa et al, 2002; Hugdahl, 1995; Boucsein, 1992; Van Der Zwaag et al, 2011). This finding does not relate to some literature, however there are mixed views and other studies show that the mode of music can in fact have an influence upon skin conductance (Lundqvist et al, 2009; Baumgartner et al, 2006). The findings from this study do provide further evidence to the argument that mode, not tempo can influence skin conductance, however there is much research on each side of the argument and perhaps there are other mechanisms at work, this will be discussed later. Overall it is not possible to accept this hypothesis, it is correct in that fast tempo returned higher subjective ratings of arousal, however no such effect was found for skin conductance.



In another hypothesis it was predicted that major mode music would produce higher subjective scores of positive valence and lower measures of heart rate than minor music. The results from this study do provide sufficient evidence to accept this hypothesis. Major mode music returned significantly lower heart rates than minor mode music. This finding is in line with other literature (Andreassi, 2007; Krumhansl, 1997), however there is contradicting evidence relating to the validity of heart rate as an indication of valence (Hodges, 2010). Results from the subjective measures of valence also provide significant results; major mode music returned greater scores of positive valence and minor mode music returned greater scores of negative valence. This finding is in line with relevant literature and can be considered highly reliable (Webster & Weir, 2005; Gregory, Worrall & Sarge, 1996; Khalfa et al, 2005). It is possible to accept this hypothesis as all criteria stated is in line with this study's findings.

One finding that does not relate to any of this study's hypothesis is the influence mode was found to have upon subjective measures of tension. Minor mode music conditions showed significantly higher scores of tension than major mode music did. This finding is in line with literature (Bigand et al, 1996) and would be expected as minor mode music does inherently sound tenser. However other research suggests that it is in fact tempo that should modulate tension, not musical mode (Van Der Zwaag et al, 2011). This finding lends support to the argument that it is music mode which can influence subjective levels of tension; however this topic is still debated and requires further research.

### **The influence of mode on heart rate and skin conductance**

In this study significant effects were observed for an effect of mode on both heart rate and skin conductance. This was unexpected and conflicts with much research as tempo was expected to influence skin conductance, not mode (Hugdahl, 1995, Boucsein, 1992). The aspect of musical mode is related to the valence dimension of emotion (Webster & Weir, 2005; Gregory, Worrall & Sarge, 1996; Khalfa et al, 2005), this relationship is extremely reliable and there is no evidence to suggest otherwise. The fact that a significant effect was found for modes influence on skin conductance could in fact suggest that in this study skin conductance was not a valid measure of arousal, and that in this instance skin conductance was actually measuring participant's valence levels. This theory does have some backing as skin conductance has been shown to be an indicator of valence levels (Lundqvist et al, 2009; Baumgartner et al, 2006) however most research states that skin conductance is more closely related to arousal (Khalifa et al, 2002; Hugdahl, 1995; Boucsein, 1992). This study is a replication of Van Der Zwaag et al's (2011) study with certain methodological changes. Van Der Zwaag et al (2011) found that more arousal was reported during minor mode conditions, however in the current study mode showed no significant relationship with arousal. One explanation for this difference could be explained by a certain methodological change in this study. This study presented music to participants in the foreground and asked participants to relax and give the music their full attention, Van Der Zwaag et al (2011) however presented music to participants as background noise and had participants perform an office task whilst each musical condition was played. When music is presented in the foreground it allows participants to listen to the music in greater detail, hearing and experiencing every melody and harmony fully. If music is in the background participants will not

have this same experience and may only be able to unconsciously react to the music's mode and tempo. The difference between background and foreground music presentation could provide answers for the conflicting results. When something other than music is your focus of attention the characteristics of music could influence you in different ways than when listening to music is your primary focus. When listening to music people can report shivers and other bodily reactions (Webster & Weir, 2005), this shows that when in the foreground music can influence us very deeply. However when music is played in the background whilst a task is performed it is much less likely to affect us in this way. In essence whether music is listened to in the background or foreground could alter our emotional reactions, so therefore it is possible that having music as a primary focus could cause explain why mode affected both physiological measures. The results of a correlational analysis do show that participant's changes in heart rates are correlated with participant's changes in skin conductance; this supports this theory as it suggests that there an underlying factor influencing both measures. There is little to no research available around the differing effects of background and foreground music, therefore I would suggest that a suitable follow up study would be to investigate this effect.

There is however other possible explanations for the unexpected results relating to mode. Measures such as skin conductance and tension were expected to be influenced by the tempo of music. However this was not the case as they were instead influenced by the mode that music was presented in. One explanation for this could be that the difference in tempo between fast and slow conditions was just too small. Major and minor conditions sound extremely different to each other; whilst the changes between fast and slow conditions of tempo are noticeable it is not nearly as noticeable as the changes in mode. It could be that the difference in mode simply overshadowed the changes in tempo, causing mode to influence both physiological and subjective measures much more. Whilst this could be true, the difference between fast and slow tempo conditions in this study was identical to the differences used in Van Der Zwaag et al's (2011) study. However as stated before the effect of changing tempo when music is played in the background could be different to if music is played in the foreground. In order to assess this theory if this study was to be repeated additional tempo conditions could be included to create much more extreme values which could in theory cause greater effects on participants subjective and physical measures.

Another possible explanation for this unexpected finding involves musical familiarity. In Van Der Zwaag's et al's (2011) study participants were played popular rock and pop music tracks, which participants were most likely to have heard before. This familiarity with the music could affect the ways in which participants respond to the music physiologically. When we first hear a musical track we do not know what to expect, this can lead to greater numbers of violations in our expectation of the music. This idea links with one of Juslin & Västfjäll's (2008) mechanisms for music's emotional influence, the mechanism of musical expectancy described how arousal can occur when music violates our expectation which is a process that will occur much more often in new music. This study utilised music that all participants should not have heard before, therefore participants arousal levels could be increased greatly for every condition. This higher state of arousal may have caused participants skin conductance levels to change by less for each condition. In van der Zwaag et al's (2011) study participant's musical familiarity could have allowed aspects such as

tempo to influence them by a much greater amount due to the overall lower arousal levels experienced. In order to fix this possible confounding effect participants could be allowed time before the experiment begins to familiarise themselves with the music. This would reduce the number of expectancy violations participants experience and could therefore allow participants baseline arousal to lower, this also allows the methodology to utilise songs that participants may not have heard before the experiment which reduces any associations that participants may have with the music.

### **Issues concerning heart rate as a measure of valence**

This study's results show that the mode of music does influence measures of heart rate. However as stated previously there are problems with the validity of heart rate as a measure of valence (Hodges, 2010). Heart rate is directly related to activity in the autonomic nervous system (Pomeranz et al, 1985) and therefore should be an appropriate measure of valence (Kreibig, 2010; Muth et al, 1999). However as there are certain problems with the use of heart rate as a measure of valence this could be considered a flaw of the current study. Other measures do exist which would be a more appropriate and valid. Measures of skin temperature have been proven as a reliable and valid measure of valence (Rimm-Kaufman & Kagan, 1996; McFarland & Kennison, 1989), replacing measures of heart rate with this much more reliable measure could provide great improvement to this study's methodology. An alternative replacement involves facial EMG measures, which have also been proven as reliable indicators of valence levels (Cacioppo et al, 1986; Witvliet, 1998). Altering the valence measures used in this study could provide much more reliable results, however in relation to valence this study did find the expected results in line with much other literature. Whilst the results of this study were expected if it was to be repeated I would suggest use of valence measures that are not as debateable as heart rate.

### **Subjective measurements**

This study utilised multiple measures of emotion, physiological recordings were conducted as well as obtaining subjective data from participants. This was done in hopes of physiological and subjective measure being able to cross validate each other, which has proven true. Results show a significant effect between heart rate and mode, as literature would suggest this indicates participants experiencing different levels of valence. When the subjective measures of this are included we can see that they do in fact cross validate each other. Subjective measurements show that during conditions where participants experienced the lower heart rates associated with positive valence levels, participants also subjectively responded as experiencing higher levels of positive valence. This provides evidence for the cross validation of measures and also supplies justification for the use of multiple physiological and subjective measures.

### **Ecological validity**

This study utilised an experimental approach where participants carried out conditions in a laboratory setting. Whilst some would argue that this is not ecologically valid (Van Der Zwaag et al, 2011), there are some factors that would

actually suggest otherwise. Music is listened to in many different situations; some situations are more socially orientated whilst others are individual and relaxing. In this study music was presented to participants sitting in a comfortable chair with music being their primary focus. I argue that this situation is in fact not too different from how many individuals listen to music in their own home. Traditional ecologically valid research would present music alongside another task or activity such. An individual who is attempting to modify their emotional state using music would most often not perform these tasks, and would simply sit or lie down and listen to the music. Additionally even when on the go music is not always a supplement to tasks. Travellers will often sit down on a train or bus and listen to music to pass the time, this is one example where the methodology of this study matches real world music listening. However there are other situations where this methodology does not match real world music listening. For example individuals often listen to music whilst exercising or whilst driving. It is true that for these forms of music listening this study's methodology does not contain great ecological validity, however as stated beforehand there are many other situations of real world music listening that match this study's methodology extremely well.

## **Implications**

There are multiple implications of the results from this study that could have an influence upon our knowledge of musically induced emotions. Firstly whilst there are problems using heart rate as a measure of valence levels, this study's results lend support to heart rates use as a valence measure. As results from this study found a relationship between musical mode, heart rate and subjective valence levels we can suggest from these results that in this case heart rate was a suitable measure of valence. Further implications of this research also support the use of music as a therapy. As described in the introduction music therapy can be used to induce greater relaxation and other benefits in cancer patients. However as this study found listening to major mode music increased participants subjective positive valence levels we can add support for the use of music therapy as a treatment for certain psychological disorders. Music therapy has been found to be effective in reducing symptoms of depression (Maratos et al, 2008), with the findings from this study it is not difficult to believe. If participants listening to major music show higher levels of positive valence, then the intervention of music therapy certainly could assist individuals with depressive disorders.

There are also a number of questions raised by this study. As described earlier in this discussion, due to differing results between this study and Van Der Zwaag et al's (2011) could the context in which music is listened to affect how individuals respond physiologically. This question is currently unable to be answered as there is no research into this very niche concept. However with this question now raised future research could look into investigating this effect. As also stated earlier the question of whether heart rate is a valid measurement of valence was raised. Whilst there is evidence to suggest that heart rate is a valid and reliable measure of valence levels there are other measures that do not have the same problem. Further research could look into validating heart rate as a measure of valence. Additionally the question of why this study did not observe an effect of tempo on skin conductance levels. Literature does indicate that skin conductance should be affected by tempo, however in this study this was not the case.

## Conclusion

This study found both some expected and unexpected results. Whilst one hypothesis relating to musical modes effect upon heart rate and subjective valence was found to be correct, another hypothesis relating to musical tempo's influence upon skin conductance and subjective arousal provided conflicting results. This study as expected found that when participants were played major mode music subjective positive valence levels increased whilst heart rate levels decreased. Additionally increases in music's tempo as expected was found to increase participant's subjective arousal levels, however in an unexpected finding this same change did not show any effect upon skin conductance levels. This study shows that the musical characteristics of mode and tempo do have an influence upon our emotions and that modifying these characteristics can produce different emotional responses, this knowledge could prove to be extremely useful in the alleviation and treatment of mood disorders and the development of music therapy. Overall the findings from this study are extremely interesting and questions raised could lend inspiration to new exploratory research.

## References

Andreassi, J. (2007). *Psychophysiology*. 5th ed. London: Lawrence Erlbaum Associates. 264-265.

Andreassi, J. (2007). *Psychophysiology*. 5th ed. London: Lawrence Erlbaum Associates. 65-66

Balkwill, L. Thompson, W. (1999). A Cross-Cultural Investigation of the Perception of Emotion in Music: Psychophysical and Cultural Cues. *Music Perception: An Interdisciplinary Journal* [On-line]. Vol. 17, No. 1, 43-64. Available from: <http://www.jstor.org/discover/10.2307/40285811?uid=3738032&uid=2&uid=4&sid=21100718037471> [Accessed 10 May 2012].

Baumgartner, T. Esslen, M. Jäncke, L. (2006). From emotion perception to emotion experience: Emotions evoked by pictures and classical music. *International Journal of Psychophysiology* [On-line]. Vol. 60, No. 1, 34-43. Available from: <http://www.sciencedirect.com/science/article/pii/S0167876005001327> [Accessed 28 March 2012].

Berntson, G. Bigger, T. Eckberg, D. Grossman, P. Kaufman, P. Malik, M. Nagaraja, H. Porges, S. Saul, P. Stone. Ven Der Molen, M. (1997). Heart rate variability: Origins, Methods, and interpretive caveats. *Psychophysiology* [On-line]. Vol. 34, 623-648. Available from: <https://sprweb.org/articles/Berntson97.pdf> [Accessed 15 May 2012].

Bigand, E. Parncutt, R. Lerdahl, F. (1996).. Perception of musical tension in short chord sequences: The influence of harmonic function, sensory dissonance, horizontal motion , and musical training. *Attention, Perception, & Psychophysics* [On-line]. Vol. 58, No. 1, 125-141. Available from: <http://www.springerlink.com/content/089886511p423142/> [Accessed 25th April 2012].

- Boucsein, W. (1992).. *Electrodermal activity*. New York: Plenum Press.
- Boyle, G. (1985). Self-report measures of depression: some psychometric considerations. *The British journal of clinical psychology* [On-line]. Vol. 24, No. 1, 45-59. Available from: <http://www.mendeley.com/research/selfreport-measures-of-depression-some-psychometric-considerations/> [Accessed 11 May 2012].
- Bradley, M. Lang, P. (2000). Affective reactions to acoustic stimuli. *Psychophysiology* [On-line]. Vol. 37, No. 2, 204-215. Available from: <http://onlinelibrary.wiley.com/doi/10.1111/1469-8986.3720204/abstract> [Accessed 15 May 2012].
- Brosschot, J. Thayer, J. (2003). Heart rate response is longer after negative emotions than after positive emotions. *International Journal of Psychophysiology* [On-line]. Vol. 50, No. 3, 181-187. Available from: <http://psycnet.apa.org/psycinfo/2003-10535-001> [Accessed 15 May 2012].
- Bunt, L. Pavlicevic, M. (2001). Music and emotion: Perspectives from music therapy. In Juslin, P. Sloboda, J. (2001). *Music and emotion: Theory and research*. pp.181-201. New York: Oxford University Press
- Burns, S. Harbuz, M. Hucklebridge, D. Bunt, L. (2001). A pilot study into the therapeutic effects of music therapy at a cancer help center. *Alternative therapies in health and medicine* [On-line]. Vol. 7, No. 1, 48-56. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/11191042> [Accessed 28 March 2012].
- Cacioppo, J. Petty, R. Losch, M. Kim, H. (1986).. Electromyographic activity over facial muscle regions can differentiate the valence and intensity of affective reactions. *Journal of Personality and Social Psychology* [On-line]. Vol. 50, No. 2, 260-268. Available from: <http://psycnet.apa.org/journals/psp/50/2/260/> [Accessed 25th April 2012].
- Cacioppo, J., Tassinary, L., & Berntson, G. (2000).. *Handbook of psychophysiology*. Cambridge: Cambridge University Press.
- Chiu, H. (2003). Using heart rate variability analysis to assess the effect of music therapy on anxiety reduction of patients. *Computers in Cardiology* [On-line]. Vol. 30, 469-472. Available from: [http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=1291194&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxppls%2Fabs\\_all.jsp%3Farnumber%3D1291194](http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=1291194&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxppls%2Fabs_all.jsp%3Farnumber%3D1291194) [Accessed 15 May 2012].
- Cockerton, T. Moore, S. Norman, D. (1997). Cognitive Test Performance and Background Music. *Perceptual and Motor Skills* [On-line]. Vol. 85, 1435-1438. Available from: <http://www.amsciepub.com/doi/abs/10.2466/pms.1997.85.3f.1435> [Accessed 15 May 2012].
- Colwell, C. (1994). Therapeutic applications of music in the whole language kindergarten. *Journal of Music Therapy* [On-line]. Vol. 31, No. 4, 238-247. Available from: <http://psycnet.apa.org/psycinfo/1995-34910-001> [Accessed 28 March 2012].

Dancey, C. Reidy, J. (2007).. *Statistics Without Maths for Psychology*. 4<sup>th</sup> ed. Essex: Pearson Education Limited

Edelberg, R. (1972).. Electrical activity of the skin: Its measurement and uses in psychophysiology. In: Greenfield, N. and Sternbach, R. *Handbook of psychophysiology*. New York: Holt, Rinehart & Winston. 367-418.

Etzel, J. Johnsen, E. Dickerson, J. Tranel, D. Adolphs, R. (2005). Cardiovascular and respiratory responses during musical mood induction. *International Journal of Psychophysiology* [On-line]. Vol. 61, 57-69. Available from: [ftp://ftp.ict.usc.edu/tparsons/Parsons\\_Readings/Parsons\\_NeuroSim\\_weekly\\_readings/NeuroSIM\\_Phys\\_Comp\\_readings/Etzel\\_Cardiovascular%20and%20respiratory%20responses%20during%20musical%20mood%20induction.pdf](ftp://ftp.ict.usc.edu/tparsons/Parsons_Readings/Parsons_NeuroSim_weekly_readings/NeuroSIM_Phys_Comp_readings/Etzel_Cardiovascular%20and%20respiratory%20responses%20during%20musical%20mood%20induction.pdf) [Accessed 15 May 2012].

Gabrielsson, A., & Lindström, E., (2010).. The role of structure in the musical expression of emotions. In P. N. Juslin & J. A. Sloboda (Eds.), *Music and emotion: Theory, research, and applications* (pp. 367–400).. Oxford: Oxford University Press.

Gomez, P. Danuser, B. (2004). Affective and physiological responses to environmental noises and music. *International Journal of Psychophysiology* [On-line]. Vol. 53, No. 2, 91-103. Available from: <http://www.sciencedirect.com/science/article/pii/S0167876004000273> [Accessed 15 May 2012].

Gregory, A. Worrall, L. Sarge, A. (1996). The development of emotional responses to music in young children. *Motivation and Emotion* [On-line]. Vol. 20, No. 4, 341-348. Available from: <http://www.springerlink.com/content/01883h2482103wj5/> [Accessed 10 May 2012].

Hevner, K. (1936). Experimental Studies of the Elements of Expression in Music. *The American Journal of Psychology* [On-line]. Vol. 48, No. 2, 246-268. Available from: <http://www.jstor.org/discover/10.2307/1415746?uid=3738032&uid=2&uid=4&sid=21100718037471> [Accessed 10 May 2012].

Hevner, K. (1937). The Affective Value of Pitch and Tempo in Music. *The American Journal of Psychology* [On-line]. Vol. 49, No. 4, 621-630. Available from: <http://www.jstor.org/discover/10.2307/1416385?uid=3738032&uid=2&uid=4&sid=56033204523> [Accessed 10 May 2012].

Hodges, D. (2010).. Psychophysiological measures. In: Juslin, P. Sloboda, J. *Handbook of Music and Emotion: Theory, Research, Applications*. Oxford: Oxford University Press. 279-312.

Hugdahl, K (1995).. *Psychophysiology*. London: Harvard University Press. 101-130.

Isen, A. (1993). Positive affect and decision making. *Handbook of emotions*. 261-277. New York: Guilford Press

Iwanaga, M. Kobayashi, A. Kawasaki, C. (2005). Heart rate variability with repetitive exposure to music. *Biological Psychology* [On-line]. Vol. 70, No. 1, 61-66. Available from: <http://www.sciencedirect.com/science/article/pii/S0301051105000049> [Accessed 15 May 2012].

Jäncke, L. (2008). Music, memory and emotion. *Journal of Biology* [On-line]. Vol. 7, No. 21. Available from: <http://jbiol.com/content/7/6/21> [Accessed 10 May 2012].

Juslin, P. Laukka, P. (2004). Expression, Perception, and Induction of Musical Emotions: A Review and a Questionnaire Study of Everyday Listening. *Journal of New Music Research* [On-line]. Vol. 33, No. 3, 217-238. Available from: <http://www.tandfonline.com/doi/abs/10.1080/0929821042000317813> [Accessed 28 March 2012].

Juslin, P. Lundqvist, L. Carlsson, F. Hilmersson, P. (2009). Emotional responses to music: experience, expression and physiology. *Psychology of Music* [On-line]. Vol. 37, No. 1, 61-90. Available from: <http://pom.sagepub.com/content/37/1/61.short> [Accessed 28 March 2012].

Juslin, P. Sloboda, J. (2010). *Handbook of Music And Emotion: Theory, Research, Applications*. New York: Oxford University Press.

Juslin, P. Västfjäll, D. (2008). Emotional responses to music: The need to consider underlying mechanisms. *Behavioural and Brain Sciences* [On-line]. Vol. 31, 559-621. Available from: [http://ppw.kuleuven.be/okp/\\_pdf/Moors2008DBTTO.pdf](http://ppw.kuleuven.be/okp/_pdf/Moors2008DBTTO.pdf) [Accessed 28 March 2012].

Kamenetsky, S. Hill, D. Trehub, S. (1997). Effect of Tempo and Dynamics on the Perception of Emotion in Music. *Psychology of Music* [On-line]. Vol. 25, No. 2, 149-160. Available from: <http://pom.sagepub.com/content/25/2/149.short> [Accessed 11 May 2012].

Kenealy, P. (1988). Validation of a music mood induction procedure: Some preliminary findings. *Cognition & Emotion* [On-line], Vol. 2, No. 1, 41-48. Available from: <http://www.tandfonline.com/doi/abs/10.1080/02699938808415228> [Accessed 28 March 2012].

Khalifa, S. Isabelle, P. Jean-Pierre, B. Manon, R. (2002). Event-related skin conductance responses to musical emotions in humans.

Khalifa, S. Schon, D. Anton, J. Liégeois-Chauvel, C. (2005). Brain regions involved in the recognition of happiness and sadness in music. *Neuroreport* [On-line]. Vol. 16, No. 18, 1981-1984. Available from: [http://journals.lww.com/neuroreport/Abstract/2005/12190/Brain\\_regions\\_involved\\_in\\_the\\_recognition\\_of.2.aspx](http://journals.lww.com/neuroreport/Abstract/2005/12190/Brain_regions_involved_in_the_recognition_of.2.aspx) [Accessed 24th April 2012].

Kreibig, S. (2010).. Autonomic nervous system activity in emotion: A review. *Biological Psychology* [On-line]. Vol. 84, No. 3, 394-421. Available from:



<http://www.sciencedirect.com/science/article/pii/S0301051110000827> [Accessed 25th April 2012].

Krumhansl, C. (1997). An exploratory study of musical emotions and psychophysiology. *Canadian Journal of Experimental Psychology* [On-line]. Vol. 51, No. 4, 336-353. Available from: <http://psycnet.apa.org/journals/cep/51/4/336/> [Accessed 28 March 2012].

Krumhansl, C. (2002). Music: A Link Between Cognition and Emotion. *Current Directions in Psychological Science* [On-line]. Vol. 11, No. 2, 45-50. Available from: <http://cdp.sagepub.com/content/11/2/45.full.pdf+html> [Accessed 10 May 2012].

Lane, A. Davis, P. Devonport, T. (2011). Effects of music interventions on emotional states and running performance. *Journal of Sports Science and Medicine* [On-line]. Vol. 10, 400-407. Available from: <http://www.jssm.org/vol10/n2/22/v10n2-22pdf.pdf> [Accessed 28 March 2012].

Lang, P. (1995). The emotion probe: Studies of motivation and attention. *American Psychologist* [On-line]. Vol. 50, No. 5, 372-385. Available from: <http://psycnet.apa.org/journals/amp/50/5/372/> [Accessed 10 May 2012].

Lee, A. Sternthal, B. (1999). The effects of Positive Mood on Memory. *Journal of Consumer Research* [On-line]. Vol. 26, No. 2, 115-127. Available from: <http://www.jstor.org/discover/10.1086/209554?uid=3738032&uid=2&uid=4&sid=47698815548317> [Accessed 28 March 2012].

Lundqvist, L. Carlsson, F. Hilmersson, P. Juslin, P. (2009). Emotional responses to music: experience, expression, and physiology. *Psychology of Music* [On-line]. Vol. 37, No. 1, 61-90. Available from: <http://pom.sagepub.com/content/37/1/61.short> [Accessed 15 May 2012].

Malik, M. (1996). Heart Rate variability. *Annals of Noninvasive Electrocardiology* [On-line]. Vol. 1, No. 2, 151-181. Available from: <http://onlinelibrary.wiley.com/doi/10.1111/j.1542-474X.1996.tb00275.x/abstract> [Accessed 15 May 2012].

Maratos, A. Gold, C. Wang, X. Crawford, M. (2008).. Music therapy for depression. *Cochrane Database of Systematic Reviews* [On-line]. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/18254052> [Accessed 25th April 2012].

Mattila, A. Wirtz, J. (2001). Congruency of scent and music as a driver of in-store evaluations and behaviour. *Journal of Retailing* [On-line]. Vol. 77, No. 2, 273-289. Available from: <http://www.sciencedirect.com/science/article/pii/S0022435901000422> [Accessed 24th April 2012].

McFarland, R. Kennison, R. (1989). Asymmetry in the relationship between finger temperature changes and emotional state in males. *Applied Psychophysiology and Biofeedback* [On-line]. Vol. 14, No. 4, 281-290. Available from: <http://www.springerlink.com/content/m778h6204uq32374/> [Accessed 25th April 2012].

Möckel, M. Röcker, L. Störk, T. Vollert, J. Danne, O. Eichstädt, H. Müller, R. Hochrein, H. (1994). Immediate physiological responses of healthy volunteers to different types of music: cardiovascular, hormonal and mental changes. *European Journal of Applied Physiology and Occupational Physiology* [On-line]. Vol. 68, No. 6, 451-459. Available from: <http://www.springerlink.com/content/p6440w1v6w548360/> [Accessed 15 May 2012].

Menon, V. Levitin, D. (2005). The rewards of music listening: Response and physiological connectivity of the mesolimbic system. *NeuroImage* [On-line]. Vol. 28, No. 1, 175-184. Available from: <http://www.sciencedirect.com/science/article/pii/S1053811905004052> [Accessed 28 March 2012].

Muth, E. Koch, K. Stern, R. Thayer, J. (1999).. Effect of Autonomic Nervous System Manipulations on Gastric Myoelectrical Activity and Emotional Responses in Healthy Human Subjects. *Psychosomatic Medicine* [On-line]. Vol. 61, No. 3, 297-303. Available from: <http://www.psychosomaticmedicine.org/content/61/3/297.short> [Accessed 25th April 2012].

Nyklíček, I. Thayer, J. Van Doornen, L. (1997). Cardiorespiratory differentiation of musically-induced emotions. *Journal of Psychophysiology* [On-line]. Vol. 11, No. 4, 304-321. Available from: <http://psycnet.apa.org/psycinfo/1997-41450-002> [Accessed 15 May 2012].

Palomba, D. Angrilli, A. Mini, A. (1997). Visual evoked potentials, heart rate responses and memory to emotional pictorial stimuli. *International Journal of Psychophysiology* [On-line]. Vol 27, No. 1, 55-67. Available from: <http://psycnet.apa.org/psycinfo/1997-06202-006> [Accessed 15 May 2012].

Pearce, K. (1981). Effects of different types of music on physical strength. *Perceptual and Motor Skills* [On-line]. Vol. 53, 351-352. Available from: <http://www.amsciepub.com/doi/abs/10.2466/pms.1981.53.2.351> [Accessed 15 May 2012].

Pomeranz, B. Macaulay, R. Caudill, M. Kutz, I. Adam, D. Gordon, D. Kilborn, K. Barger, A. Shannon, D. Cohen, R. (1985). Assessment of autonomic function in humans by heart rate spectral analysis. *American Journal of Physiology: Heart and Circulatory Physiology* [On-line]. Vol. 248, No. 1, 151-153. Available from: <http://ajpheart.physiology.org/content/248/1/H151.short> [Accessed 15 May 2012].

Rauscher, F. Shaw, G. Ky, K. (1995). Listening to Mozart enhances spatial-temporal reasoning: towards a neurophysiological basis. *Neuroscience Letters* [On-line]. Vol. 185, No. 1, 44-47. Available from: <http://www.sciencedirect.com/science/article/pii/0304394094112214> [Accessed 28 March 2012].

Riganello, F. Candelieri, A. Quintieri, M. Dolce, G. (2010). Heart rate variability, emotions, and music. *Journal of Psychophysiology* [On-line]. Vol. 24, No. 2, 112-119.

Available from: <http://psycnet.apa.org/journals/jop/24/2/112/> [Accessed 15 May 2012].

Rimm-Kaufman, S. Kagan, J. (1996). The psychological significance of changes in skin temperature. *Motivation and Emotion* [On-line]. Vol. 20, No. 1, 63-78. Available from: <http://www.springerlink.com/content/y725761343t18213/> [Accessed 25th April 2012].

Robinson, J. (2005). *Deeper Than Reason: Emotion And Its Role in Literature, Music and Art*. New York: Oxford University Press.

Russel, J. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology* [On-line]. Vol. 39, No. 6, 1161-1178. Available from: <http://psycnet.apa.org/psycinfo/1981-25062-001> [Accessed 10 May 2012].

Saarikallio, S., & Erkkilä, J. (2007).. The role of music in adolescents' mood regulation. *Psychology of Music*, 35, 88–109.

Scheier, M. Carver, C. (1977). Self-focused attention and the experience of emotion: Attraction, repulsion, elation, and depression. *Journal of Personality and Social Psychology* [On-line]. Vol. 35, No. 9, 625-636. Available from: <http://psycnet.apa.org/journals/psp/35/9/625/> [Accessed 28 March 2012].

Scherer, K. (2004). Which Emotions Can be Induced by Music? What Are the Underlying Mechanisms? And How Can We Measure Them? *Journal of New Music Research* [On-line]. Vol. 33, No. 3, 239-251. Available from: <http://www.tandfonline.com/doi/abs/10.1080/0929821042000317822> [Accessed 28 March 2012].

Schulkind, M. Hennis, L. Rubin, D. (1999). Music, emotion, and autobiographical memory: They're playing your song. *Memory & Cognition* [On-line]. Vol. 27, No. 6, 948-955. Available from: <http://www.springerlink.com/content/68u1u314134kw321/> [Accessed 10 May 2012].

Silvia, P. (2002). Self-awareness and emotional intensity. *Cognition & Emotion* [On-line]. Vol. 16, No. 2, 195-216. Available from: <http://www.tandfonline.com/doi/abs/10.1080/02699930143000310> [Accessed 28 March 2012].

Spatz, C., & Kardas, E. (2007).. *Research methods in psychology: Ideas, techniques, and reports*. Boston, MA: McGraw-Hill.

SPSS Inc. (2007). *SPSS Base 17.0 for Windows User's Guide*. SPSS Inc., Chicago IL.

Steinbeis, N. Koelsch, S. Sloboda, J. (2006). The Role of harmonic Expectancy Violations in Musical Emotions: Evidence from Subjective, Physiological, and Neural Responses. *Journal of Cognitive Neuroscience* [On-line]. Vol. 18, No. 8, 1380-1393. Available from: <http://www.mitpressjournals.org/doi/abs/10.1162/jocn.2006.18.8.1380> [Accessed 10 May 2012].

Thayer, R. Newman, R. McClain, T. (1994). Self-regulation of mood: Strategies for changing a bad mood, raising energy, and reducing tension. *Journal of Personality and Social Psychology* [On-line]. Vol. 67, No. 5, 910-925. Available from: <http://psycnet.apa.org/journals/psp/67/5/910/> [Accessed 28 March 2012].

Thompson, W. Coltheart, M. (2008). The role of signal detection and amplification in the induction of emotion by music. *Behavioural and Brain Sciences* [On-line]. Vol. 31, 597-598. Available from: <http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=2335672> [Accessed 10 May 2012].

Van Der Zwaag, M. Westerink, J. Broek, E. (2011). Emotional and psychophysiological responses to tempo, mode, and percussiveness. *Musicae Scientiae* [On-line]. Vol.15, No.2, 250-269. Available from: <http://msx.sagepub.com/content/15/2/250.short> [Accessed 28 March 2012].

Webster, G. Weir, C. (2005). Emotional Responses to Music: Interactive effects of Mode, Texture, and Tempo. *Motivation and Emotion* [On-line]. Vol. 29, No. 1, 19-39. Available from: <http://www.springerlink.com/content/k43162kpj0714047/> [Accessed 10 May 2012].

Whorwell, P. Houghton, L. Taylor, E. Maxton, D. (1992). Physiological effects of emotion: assessment via hypnosis. *The Lancet* [On-line]. Vol. 340, No. 8811, 69-72. Available from: <http://www.sciencedirect.com/science/article/pii/0140673692903941> [Accessed 28 March 2012].

Willhelm, P. Schoebi, D. (2007). Assessing mood in daily life: Structural validity, sensitivity to change, and reliability of a short-scale to measure three basic dimensions of mood. *European Journal of Psychological Assessment* [On-line]. Vol. 23, No. 4, 258-267. Available from: <http://psycnet.apa.org/journals/jpa/23/4/258/> [Accessed 10 May 2012].

Willow Software. (1997). Anvil Studio, 2012.04.07. Shorelin, WA: Willow Software

Witvliet, C. (1998). The impact of music-prompted emotional valence and arousal on self-report, autonomic, facial EMG, and startle responses across experimental contexts. *Dissertation Abstracts International: Section B: The Sciences and Engineering* [On-line]. Vol. 58, No. 12-B, 6832. Available from: <http://psycnet.apa.org/psycinfo/1998-95012-215> [Accessed 25th April 2012].