EFFECTS OF VISUAL STIMULI ON MUSICALLY-INDUCED CHILLS RESPONSE

By

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Statement of Authentication

The work presented in this thesis is, to the best of my knowledge and belief, original except as acknowledged in the text. I hereby declare that I have not submitted this material, either in full or in part, for a degree at this or any other institution.

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Abstract

Experiences of chills are one of the peak experiences reported in the context of response to art and are experienced by half to two thirds of the population. Previous research on aesthetic chills, a peak emotional response of art appreciation, has listed multiple sensory inputs; however, there exists few studies that investigated how visual information affected musically-induced chills response. The aim of the current master's thesis was to investigate 1) whether related visual stimuli of a musical performance could enhance musically- induced chills responses and 2) whether different type of visual cues have different impact on listeners' emotional reactions and 3) whether there is a difference between individuals towards this musical reward activity.

In order to address these questions, this thesis reports two studies: a preliminary online experiment involving 82 participants and a second lab-based experiment in which 54 participants' chill-responses to music were measured using galvanic skin conductance (GSR). Both studies used three types of music presentation modalities. In the preliminary online study, music pieces were presented in audio-only (AO), audio-visual (VO) and video-only (VO) modalities, and in GSR study, audio-only (AO), audio-visual of live orchestra performance, audio-visual with natural scenery were adopted. Results of the preliminary study suggested that for people with high musical reward sensitivity, audio-visual music listening modality resulted in more chills response outcomes, whereas low and average musical reward sensitivity listeners preferred audio-only music listening modality. In the physiological study, participants' self-reported chills response is consistent with the findings in preliminary study; however, number of GSR peaks showed that low musical reward sensitivity listeners showed significantly more chills responses in audio-only listening modality than music with natural scenery, and high musical reward sensitivity listeners showed more chills responses in live performance than natural

scenery visual input. It is therefore argued that whether visual components intensify the emotional responses evoked by musical performance is an individual reaction according to listeners' musical reward sensitivity, which contributes to the emotional meanings of music.

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CHAPTER 1: INTRODUCTION

1.1 General introduction

Music has been an inseparable part of many people's lives, and an important topic for cognitive psychologists to understand the evolution, cognition and perception, development, appreciation as well as therapeutic effects of musical behaviours in human beings. Music is an ideal stimulus for eliciting emotions and expressing emotions, invoking not only affective states, but also physiological reactions (changes in heart rate, blood pressure, respiration, body temperature) and physical responses (such as muscular and motor response, body movement, chills). Among all these reactions, musical peak experiences contain a powerful, vivid and long-lasting feature. The phenomena of the experiences vary from person to person, commonly reported as shivers, tears, lump in the throats, or pilomotor (goosebumps). Researchers began to notice this from, defined as musical chills responses.

This chapter examines the trends in empirical research about musically-induced chills response, as well as cross-modal perception towards musical emotions, over the last 20 years, and subsequently, the purpose of this MRes thesis. Section 1.2, Aesthetic chills, traces the development of the concept of "chills" in music cognition and highlights the importance of chills response to aesthetic activities in contemporary society. Section 1.3, Musical reward sensitivity, identifies the relationship between the reward system in the brain and musically-induced chills response, as well as individual differences in aesthetic chills responses. Section 1.4, Visual perception and cognition in music, outlines current research in visual and auditory interaction in artistic aesthetic activities, especially music. Section 1.5, Rationale for Current research, justifies the research gap in cross-modal interaction in peak emotional responses evoked by music, and illustrates the aims and questions in current MRes project. Section 1.6, summarises the present chapter and outlines the whole thesis.

1.2 Aesthetic chills

Chills are often understood in origin, to be a kind of bodily reaction towards coldness or fear both in animals and humans (Huron, 2006). In a cold environment, the standing hair helps capture a layer of insulating hair in order to keep the heat inside bodies, which is when chills happen. In addition, when threatened by other species or external surroundings, animals as well as human beings tend to intimidate others spontaneously by making themselves appeared bigger, such as rearing up and bristling of hair. These behaviours suggest that chills possess a survival function (Huron, 2006).

Over the past few decades, the concept of chills has developed to possess a new meaning as a response to aesthetic stimuli, and is described as being a kind of peak experience we have when we are confronting sublime objects, like the Pyramids, a military parade or even a drama. To describe this physical reaction of aesthetic pleasure, the term “frisson” was discussed as the most accurate terminology (Harrison & Loui, 2014). In an early and influential paper written on aesthetic chills, Sloboda (1991) suggested that, due to the numerous descriptive terms that have been associated with this experience (chills, thrills, goosebumps, shivers, and goosetingles), researchers would benefit from borrowing the succinct French term, *frisson,* in order to provide continuity to this body of research.

Chills are usually accompanied by shivers down the spine, gooseflesh or tears. These bodily reactions indicate a result of cognitive activity, a reflection of affective change. Because of these external, readily observable responses to an object, chills can provide a context that is amenable and achievable for researchers to conduct objective measurement of emotional responses.

Chills have been studied from different perspectives. Researchers (Grewe, Katzur, Kopiez, & Altenmuller, 2011) have confirmed that multiple sensory inputs can all elicit chills, including visual, auditory, olfactory and tactile. They used pictures, sounds, music excerpts, smell of sour juices and feathers to investigate this experience through measuring a series of physiological responses on 36 participants. Among all the experimental materials, musically-induced chills were reported by listeners as distinctly pleasurable, and chill phenomenon were suggested to be a valuable indicator of strong emotions.

Numerous studies have in fact focused on the relationship between music and chills before the study mentioned above. The concept of using chills as an indicator of strong and pleasant emotions was introduced by Goldstein (1980). When participants were treated with the endorphin antagonist naloxone, they perceived fewer chills in response to music. The relation of chills to endogenous opiates shown in Goldstein's study indicated the hedonic impact of these bodily reactions. Following Goldstein's research materials, all the subsequent studies used music to elicit chills.

Researchers have investigated music chills from various perspectives and found out some factors that have an impact on individual's experience of this peak response. Sloboda (1991) found that chills are correlated with various musical structures, such as unprepared harmonies and sudden dynamic or textural changes. A more recent study (Guhn et al., 2007) presented further arguments for a direct relationship between musical structures and chills. From the features of stimuli which elicit chills, this arousal derives from the shift in energy and violations of expectations. The sudden change of music features (such as loudness, pitch, timbre, rhythm) can induce chills response.

From human beings' personality traits, it was reported that openness to experience was the primary predictor of chills (Colver, & El-Alayli, 2015). Openness refers to an individual's 'recurrent need to enlarge and examine experience' (McCrae & Costa, 1997, p. 826), especially through cognitive exploration (DeYoung, 2014). It includes 'active imagination, aesthetic sensitivity, attentiveness to inner feelings, preference for variety, intellectual curiosity, and independence of judgment' (Costa & McCrae, 1992, p. 15). However, there are also arguments that the frequency of chills depends very much on the familiarity of the listener with the music that induces the chills (e.g., Panksepp, 1995) and on the (possibly implicit) cognitive evaluation of the music (Grewe, Nagel, Kopiez, & Altenmüller, 2005; Grewe, Nagel, Kopiez, & Altenmüller, 2007b).

Several studies have demonstrated that physiological parameters of chills show a positive correlation to music arousal and come to peak when chills appear (Salimpoor, Benovoy, Longo, Cooperstock, & Zatorre, 2009), notably increased skin conductance and heart rate (Grewe, Kopiez, & Altenmu¨ller, 2009; Grewe, Nagel, Kopiez, & Altenmu¨ller, 2007; Rickard, 2004). This is because when chills happen, the sympathetic nervous system is activated, which leads to acceleration of heart rate and respiration, strengthening galvanic skin response and decreasing body temperature and blood volume pulse amplitude. All these reactions make chills easy to be detected by the skin conductance response (SCR), also known as the electrodermal response (and in older terminology as "galvanic skin response"). SCR is the phenomenon that the skin momentarily becomes a better conductor of electricity when either external or internal stimuli occur that are physiologically arousing. Therefore, chills are an ideal approach for observing and measuring peak experience and emotional arousal.

1.3 Musical reward sensitivity

This peak experience does not occur only beneath our skin's surface, but also it can change our brain activities. In 2001, Zatorre and his team conducted research using positron emission tomography (PET), and found that cerebral blood flow changes were measured in response to subject-selected music that elicited the highly pleasurable experience of "shivers-down-the-spine" or "chills". Among all the brain regions where blood flow changed, the ventral striatum was associated with consistency of reward. Furthermore, the nucleus accumbens (NAc) inside the ventral striatum releases dopamine when pleasure appears (Salimpoor, Benovoy, Larcher, Dagher, & Zatorre, 2011). Dopamine can also help us remember the musical excerpt that elicits chills. Therefore, when we hear the same piece of music, our expectation will facilitate this pleasure and increase the experience of chills. Research (Salimpoor et al., 2013) has proved that aesthetic rewards arose from interactions between the NAc and auditory cortices.

The examination of chills using PET revealed the activation of the reward system during chills in response to music (Blood & Zatorre, 2001). Structures such as the NAc, the ventral tegmental area (VTA), thalamus, insula, and anterior cingulate were found to be more active during a chill reaction, while activity in the amygdala and ventral medial prefrontal cortex was reduced. This pattern of brain activity has been observed typically during euphoria and/or pleasant emotions (Breiter et al., 1997). All the different emotions evoked by music, either positive or negative, are potentially pleasurable (Koelsch, Fritz, von Cramon, Müller & Friederici, 2006; Panksepp, 1995). The ultimate hedonic evaluation of both of these responses to music would appear to be mediated through the reward system and is related to the underlying proposed principles of musical expectancy.

A team of researchers also provided evidence of the correlation of musical reward and emotional arousal (Salimpoor, Benovoy, Longo, Cooperstock, & Zatorre, 2009). Twenty-six participants listened to self-selected intensely pleasurable music and “neutral” music that was individually selected for them based on low pleasure ratings they provided of other participants’ music. The “chills” phenomenon was used to index intensely pleasurable responses to music. During music listening, continuous real-time recordings of subjective pleasure states and simultaneous recordings of sympathetic nervous system activity, an objective measure of emotional arousal, were obtained. Results revealed a strong positive correlation between ratings of pleasure and emotional arousal. Importantly, a dissociation was revealed as individuals who did not experience pleasure also showed no significant increases in emotional arousal. These results have broader implications by demonstrating that strongly felt emotions could be rewarding in themselves in the absence of a physically tangible reward or a specific functional goal.

Furthermore, Menon and Levitin (2005) also demonstrated brain imaging evidence of the rewarding value of listening to music. They showed that listening to music strongly modulated activity in a network of mesolimbic structures involved in reward processing including the NAc and the VTA, as well as the hypothalamus and insula, which were thought to be involved in regulating autonomic and physiological responses to rewarding and emotional stimuli. Responses in the NAc and the hypothalamus were also strongly correlated across subjects, suggesting a mechanism by which listening to pleasant music evokes physiological reactions. Effective connectivity confirmed these findings, and showed significant VTA-mediated interaction of the NAc with the hypothalamus, insula, and orbitofrontal cortex. The enhanced functional and effective connectivity between brain regions mediating reward, autonomic, and cognitive processing provides insight into understanding why listening to music is one of the most rewarding and pleasurable human experiences.

The activation of the reward system in the brain when chills appear confirms that aesthetic activities can be intensely pleasurable. While all humans experience similar physiological changes during a chills-response, the moments in which we get goosebumps varies from person to person. Because our definition of pleasure is subjective, different people have different levels of sensitivity to this rewarding activity. Musical reward experience can be decomposed into five reliable factors: Musical Seeking, Emotion Evocation, Mood Regulation, Social Reward, and Sensory-Motor (Mas-Herrero et al., 2013). These factors were correlated with socio-demographic factors and measures of general sensitivity to reward and hedonic experience. Barcelona Musical Reward Questionnaire (BMRQ) was developed based on these factors to assess human's musical reward sensitivity.

With the test of people's sensitivity of musical reward, researchers (Mas-Herrero et al., 2013) found that there is a certain group of people for whom music holds no reward value. Despite normal perceptual ability and perceived reward-related responses in other domains like food, money or sex, this certain group was defined as having specific musical anhedonia. First appearing in the literature in 2014, people with musical anhedonia were reported to have no problem comprehending music, but were unable to appreciate music.

In 2016, Molina and her colleagues adopted fMRI technique to investigate three groups of participants (high, average, music anhedonic). This study provides direct evidence supporting the model of reward-auditory cortex interaction as underlying musical pleasure: People who do not experience that pleasure have selectively reduced responses in this system. Mallik's team (2017) also confirmed that music shared the same reward pathways with food, drug and sexual pleasure by assessing both psychophysiological and behavioural responses to music of naltrexone (NTX) or placebo administered participants.

1.4 Visual perception and cognition in music

One of the oldest questions in experimental psychology concerns the nature of cross-modal sensory interactions – the degree to which information from one sensory channel influences our interpretation of information arising through other sensory channels. Indeed, multisensory perception is closer to the situation of how humans perceive the object world in reality. This situation also fits in daily music listening, for example, attending a concert, watching music videos, and even the emergence of visual imagery in music appreciation.

Numerous studies have focused on the interaction between visual cues and auditory cues in music listening. These studies can be divided into two groups: studies focusing on the cognitive response to music and those focusing on the emotional response to music. In studies that focus on the cognitive aspect, the visual cues are the main predictors compared to auditory cues in social cognition, in studies ranging from communication of meaning in music perception to performance judgement (Platz, 2012; Tsay, 2013). However, in studies that concerned the emotional aspect, the results indicate that the auditory information is dominant over the visual (Kaiser & Keller, 2011; Piwek, Pollick & Petrini, 2015; Thompson, Russo & Quinto, 2008). To be specific, in 2008, a research team demonstrated that visual aspects of singing performance were automatically and pre-attentively registered and integrated with auditory cues by instructing participants to judge the emotional connotations of different presentations of song intervals.

Kaiser and Keller (2011) later confirmed that auditory cues affected the accuracy of emotion judgments. They used normal as well as exaggerated expressions of different emotions as visual stimuli and investigated how these impacted on music stimuli. Four years after Kaiser and Keller's research, Piwek and her colleagues explored audio-visual integration in emotion recognition from social interaction settings, in which stimuli consisting of the biological motion and voice of two interacting agents were applied (Piwek, Pollick & Petrini, 2015). Results indicated that when the reliability of the auditory cue was decreased participants gave more weight to the visual cue in their emotional judgments, which in turn translated into increased emotion recognition accuracy for the multisensory condition. All these studies pointed to a common mechanism that auditory inputs dominant over visual inputs in multisensory integration of emotional signals in music perception.

Researchers also provided evidence from a physiological perspective (Chapados & Levitin, 2008; Petrini, Crabbe, Sheridan & Pollick, 2011). Chapados and Levitin measured electrodermal activity (EDA) by attaching electrodes to participants' fingers when listening to music. Data demonstrated that the scaled average of EDA amplitude for audio-visual (AV) modality was significantly higher than the sum of the responses of visual-only and auditory-only modalities. Besides, EDA and subject tension judgements were found to be the most highly correlated in the AV condition than in the unimodal conditions. In 2011, Petrini's research team used event-related fMRI and located that insula and left thalamus had an active role in detecting emotional correspondence between auditory and visual information during music performances (Petrini, Crabbe, Sheridan & Pollick, 2011). These studies suggested that seeing music performances made a strong contribution to emotional responses to music or peak experiences in relation to music.

In fact, as a complex animal, humans prefer to use comprehensive functions to perceive the world. One of the founders of modern experimental psychology, Wilhelm Wundt carried out a number of experiments related to aesthetic experience. Wundt (1863) showed that arousal is related to stimulus complexity and proposed that aesthetic pleasure is evoked when the art object is optimally complex—neither too simple nor too complicated (Figure 1). Daniel Berlyne, linked Wundt's observations with contemporary neurophysiological research on pleasure. Berlyne (1971) distinguished two pleasure-inducing effects: one source of pleasure arises from moderate increases in arousal, while a second source of pleasure arises from inhibition or reduction of arousal from an uncomfortably high level. Together, these sources result in an inverted-U function when hedonic value (pleasure) is plotted against arousal level. Pleasantness (Wundt) and hedonic value (Berlyne) increase with complexity and our arousal invoked by the music, yet decrease once we reach a peak that is determined by individual variables. In fact, this could provide an interesting counter-argument that the related visual stimuli may contribute to pleasure as well as that the addition of visual stimulus could cause cognitive overload and in effect distract people from the emotional effect of the music. This diversity may derive from individual's threshold for stimulation (e.g. introverts, people's experience to stimulation in their daily activities). For example, it may be that people with low thresholds for stimulation may prefer less complexity, and people with high thresholds for stimulation may prefer relatively more complexity.

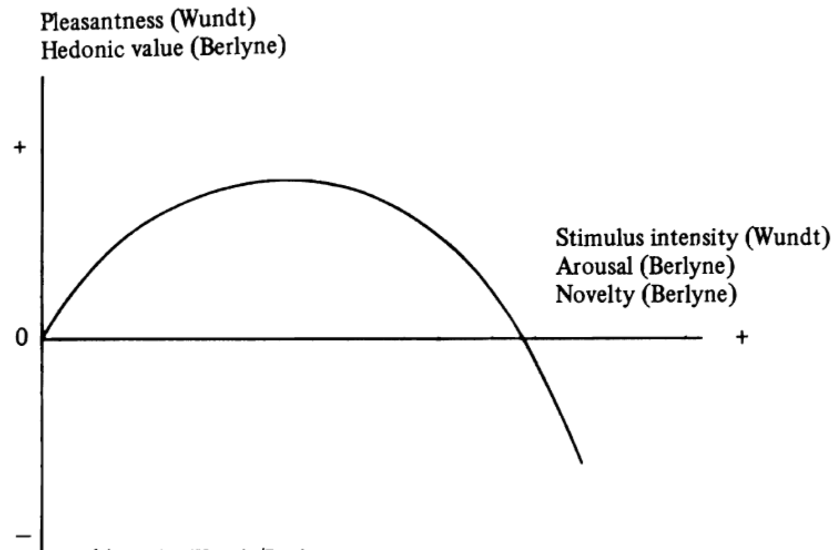

Figure 1. The Wundt/Berlyne curve (Sluckin, Hargreaves & Colman, 1983)

1.5 Rationale for Current research

As described in the sections above, several aspects can impact musically-induced chills response. The study seeks to address the under analysed gap of this audio-visual cross-modal interaction. Therefore the present study aims to compare participants' chills responses elicited by music under different listening modalities (auditory-only, visual-only and auditory-visual) as well as including analysis of several potential factors (musical training, familiarity, liking, valence and arousal) in order to account for variables that may influence this cross-modal interaction. Particularly, in section 1.2 the influence of different levels of sensitivity towards musical reward activity has been noted. Thus participants' musical reward sensitivity is another independent variable besides listening modality. More importantly, would related visual inputs help people with musical anhedonia appreciate music? The study may find the answer of this question.

Limited related research has been done on these questions before. One study measured audiences' responses to an opera performance (*Puccini's "Madama Butterfly"*), finding that the live performance induced blends of emotions characterised by high sublimity on the Geneva Emotional Music Scale (GEMS) in audience members (Baltes & Miu, 2014). During the week of the performance, participants came to the laboratory to sign an informed consent form and fill in the Toronto Empathy Questionnaire (TEQ) and the Vividness of Visual Imagery Questionnaire (VVIQ), under the supervision of a trained research assistant. In addition, participants were explained the GEMS and how they should use it to rate their emotional responses during the opera performance that they were to attend. Then, approximately 1 hour before the performance, they filled in the Positive and Negative Affect Schedule (PANAS); they were also given three copies of GEMS and instructed to assess their emotional responses to each opera act. It was emphasized that they had to fill in the GEMS immediately after each act and try to ignore distracters. Participants were also instructed to keep a count, on a scratch-paper, of the number of separate chills that they experienced during each act. The average number of chills across acts of the opera correlated positively with GEMS sublimity. Sublimity was one of three general factors grouped by the scores of GEMS assessed by participants of the emotions they felt instead of what they perceived during music listening, which included wonder, transcendence, tenderness, nostalgia, and peacefulness. Besides participants with a disposition toward more vivid visual imagery experiences more chills. While the plot of the opera, costumes, and semantic information contained can all enhance audience's emotional reaction, researchers failed to demonstrate what influence the visual aspects had in comparison to the auditory component. The live setting could also be the reason for the audiences' reaction in this study, as well as the difficulty of applying physiological measurement in live setting. Nevertheless, this study shed some light on how audiences' peak emotions interact with music performance in live situation.

Although some evidence may suggest that visual information enhances musical emotional reactions as noted above, a contrary view may be that the addition of visual stimulus could cause cognitive overload and in effect distract people from the emotional effect of the music. In a study where a group of researchers hypothesised participants had more chills reaction in audio-visual music presentation modality with recording of pianist's live performance compared to audio-only and video-only modalities ended up with an opposite conclusion (Vuoskoski, Gatti, Spence, & Clarke, 2016). In their study, they set out three modes of musical performance presentation — audio-only, video-only and audio-visual — to test participants' emotional responses. The psychophysiological results of participants' skin conductance and blood volume pulse demonstrated that the audio-only mode elicited the highest emotional arousal, and self-reports illustrated no significant differences between audio-only and audio-visual mode. However, in this study, the researchers videoed a female pianist's performance in an individual room instead of live performance situation, which may lead to less contagious cues via body movements compared with other instruments, like clarinet (Vuoskoski, Gatti, Spence, & Clarke, 2016).

When we receive emotional cues, the dorsal anterior cingulate cortex is associated with emotional reaction. This structure, along with the hypothalamus and insula, are activated in autonomic nervous system arousal and associated with physiological responses to music. So, how does visual stimuli elicit goosebumps? The answer lies with the insula, which controls the body's connection to aesthetic stimuli (Petrini, Crabbe, Sheridan & Pollick, 2011). When the audience is listening to music, portions of the temporal cortex send perceptual and cognitive representations of musical components such as melody, harmony, timbre, meter, tempo, phrasing, lyric etc. to many other brain areas. Relevant visuals could speed up the temporal cortex message delivery process and therefore intensity the response.

The above subsections have introduced the relevant literature pertaining to the importance of aesthetic chills response in empirical research, followed by a review of literature pertaining to the relationship between musically-induced peak experience (chills) and reward system, as well as audio-visual integration in musical emotions involving the music perception domain. However, previous studies have not investigated the relationship between these factors. Therefore, the present master thesis intends to investigate listeners' chills response across different music presentation modalities (audio-visual, audio-only, video-only). Particularly, the individual differences across participants' musical reward sensitivity is included as another independent variable. Consequently, the following questions were formulated:

1. Do related visual resources have an impact on chills responses evoked by music? And if so,

   1.A. Do they facilitate and increase the degree of chills response?

   1.B. Do they overload music listening and appreciation process?

2. Do people with different levels of musical reward sensitivity experience different levels of chills in response to visual, auditory or visual-auditory stimuli?
3. Do different visual materials have different effects on reactions to emotional peak experience?

To address these questions the present thesis reports the results of two experiments. The first experiment (reported in Chapter 2) addresses question 1 and question 2 by applying an online experiment in order to gather a relatively large sample size in a short timeframe. The music stimuli that we used followed previous studies, and music pieces have been tested to be reliable chills inducers (Grewe, Katzur, Kopiez, & Altenmuller, 2011). Visual materials refer to the videos of live orchestra performance found on YouTube, as the same artists and orchestra reported by researchers. And BMRQ was adopted to classify participants' musical reward sensitivity. Chapter 3 addressed question 3 by measuring participants' skin conductance in a lab setting. Besides, another type of visual materials, natural sceneries, were applied as the themes of the classical music we used were all nature-related.

Specific hypotheses for each study are comprehensively addressed in each Chapter. However, in general, it was expected that participants with high musical reward sensitivity would experience greater chills response in audio-visual modality than audio-only and video-only modality, and that average musical reward sensitivity participants would have more chills in the audio-only listening modality compared to audio-visual modality and video-only modality. We expected that no chills would be elicited in low musical reward sensitivity participants.

1.6 Chapter summary and thesis outline

Chapter 1 introduced the overall aim of the thesis which is to investigate how music presentation modalities in different sensory domains impact listeners' chills response, as well as the relationship of listeners' musical reward sensitivity towards this reaction. After reviewing relevant studies that investigate the importance of aesthetic chills, the unique attributes of this thesis were discussed. In particular, this thesis collects both self-report evidence as well as physiological evidence to explore the research questions. Moreover, this is the first project to investigate listeners' chills response in different music presentation modalities classified by their musical reward sensitivity. The type of visual stimuli used is also different to previous studies as videos of live orchestra performance and pictures of natural scenery were applied.

As described above, Chapters 2 and 3 report the experiments conducted in this thesis. Chapter 2 present the results of an online experiment that collect listeners' self-report chills response in three different music presentation modalities (audio-visual, audio-only, video-only) to answer research question 1 and 2. Chapter 3 assesses the listeners' skin conductance response as well as their self-report chills response (button press) in a lab setting to answer question 3. Chapter 4 concludes with a general discussion of the key findings and observations as well as suggestions for future research.

CHAPTER 2: STUDY 1

The present Chapter addresses research question 1. Do related visual resources have an impact on human's chills responses evoked by music? And if so, do they facilitate and increase the degree of chills response? Alternatively, do they overload individual's music listening and appreciation process? And question 2. Do different people identified by different musical reward sensitivity have different reaction to the first question? To address these questions, participants were recruited to participate in an online experiment. The benefit of conducting an online experiment is the possibility to collect a relatively large sample size. Since this is the first study to explore the relationship between listeners' musical reward sensitivity and musically-induced chills response under different sensory domains, thus, it is ideal to receive some feedback in order to design a better lab study according to the results of this preliminary study.

As an exploratory study to apply videos of live orchestra performance, it is reliable to test whether the method for delivering the visual stimuli is useful in this preliminary study. Moreover, it is also expected to test if the musical stimuli are appropriate for the sample. Since previous research reported a positive relationship between familiarity and music chills, and most of them asked participants to bring their own chill-inducing music. In order to compare chills responses across each individual, we chose standard music pieces for all participants.

2.1 Hypotheses

H1. People with high levels of musical reward sensitivity report higher chills responses when presented with audio and related visual materials, than when presented with audio stimuli only.

H2. People with an average level of musical reward sensitivity report higher chills responses when presented with audio stimuli only, than when presented with audio-visual material.

H3. The overall chills responses in high musical reward sensitivity group are higher than that in average musical reward sensitivity group.

H4. No chills responses elicited in low musical reward sensitivity group.

H5. No chills responses elicited when presented visual material only in all participants.

2.2 Methods

This study was an online experiment with participants' self-reported chills on a scale of one to ten after they listen to each music excerpt (Wassiliwizky, Wagner, Jacobsen & Menninghaus, 2015). Participants were also required to complete pre and post measures of demographic information and music evaluation information, and listened to music in three conditions: audio-visual (AV), audio-only (AO), video-only (VO). Participants' musical reward sensitivity was defined and divided by the scores of Barcelona Musical Reward Questionnaire (BMRQ).

2.2.1 Participants

Participants were recruited by posting notices on websites listing research studies such as 'Survey Circle', 'Online Psych Research', and 'Psychology Research on the Net', posting notices on Music Psychology interest pages on social media, and via email through the social networks of the researchers. During a six-week period of data collection, we gathered responses from 123 individuals. Invalid data with missing values was excluded (n=41, 32 uncompleted survey and 9 not listening to music) leaving a total sample size of 82. There were 50 females, and 32 males, mean age was 35.55, SD = 15.53, range 18-75. Among all the participants, 29 participants reported more than three years of music training experience, 18 reported one to three years of music training, and 35 participants reported no music training at all.

2.2.2 Stimuli

In order to compare chill reactions directly, western classical music was used as standard music stimuli for all the participants (Egermann, Sutherland, Grewe, Nagel, Kopiez & Altenmüller, 2011; Grewe, Katzur, Kopiez & Altenmuller, 2011). There are two reasons for using classical music: first the emotional arousal of classical music is well analysed in quantitative methods (Koelsch et al., 2006); second, instrumental music can avoid the semantic information (lyrics) which may trigger emotional arousal. Lyrics could evoke extra musical meaning which would make it difficult to distinguish whether it was the music causing the emotional effect or not.

We chose three best chills elicited classical music pieces from two previous studies (Table 1). As investigated by Lamont (2012), over half the strong experiences occurred with classical music among undergraduates and graduate students. The visual stimuli were videos of live orchestra performance, as the same version of artists and orchestra from previous studies. All music pieces were trimmed the first 70 seconds as experimental excerpts. In order to keep participants' attention and avoid over burdening them, we decided to play one-minute excerpts instead of the whole piece of music, this is a sufficient length to elicit the desired response (Garrido, 2014).

Table 1. Musical stimuli (Egermann, Sutherland, Grewe, Nagel, Kopiez & Altenmüller, 2011; Grewe, Katzur, Kopiez, & Altenmuller, 2011)

	Title	Composer	Orchestra
Excerpt 1	*“The Moldau”*	*Bedrˇich Smetana*	*Gimnazija Kranj Symphony Orchestra*
Excerpt 2	*“Hebrides Overture”, Op. 26*	*Felix Mendelssohn*	*Philharmonic Orchestra*
Excerpt 3	*The Four Seasons–Summer– Presto*	*Antonio Vivaldi*	*H.-J. Walther und das Hamburger Kammerorchester*

2.2.3 Measures

The current experiment was embedded within an online survey, and Qualtrics was used to design the whole survey procedure. There were four sections in the survey: demographic data, musical reward sensitivity, self-reported chills and open-end reflection. Demographic data includes age, gender, musical education and activities.

The Barcelona Musical Reward Questionnaire (BMRQ) was used to measure participants’ musical reward sensitivity (Mas-Herrero et al., 2013). The BMRQ is a reliable questionnaire for detecting participants’ musical reward sensitivity. There are 20 items in the BMRQ, with four items in each of the five factors (Musical Seeking, Emotion Evocation, Mood Regulation, Social Reward, and Sensory-Motor) respectively. Each item is a statement and participants were required to indicate to what extent they agreed with the statement on a five scale from completely disagree to completely agree (for a full version of BMRQ, see Appendix A). Participants were categorised into three groups according to their score of BMRQ: high, average or low sensitivity to musical reward (Mas-Herrero, Zatorre, Rodriguez-Fornells & Marco-Pallares, 2014; Molina, Herrero, Fornells, Zatorre & Pallares, 2016).

In self-reported chills section, participants can rate their chills response after they listened to music on a scale from 0 to 10. Scale was put after each listening modality. At last, participants were asked to rate their familiarity and liking for the music they listened to, as well as valence and arousal level of the music on a scale from 0 to 10. In addition, an open-end question asking 'What were you thinking when listening to music?' was the final question (for a full version of experimental questions, see Appendix A).

2.2.4 Procedure

Data were collected by means of an online survey. The opening page of the survey included information relating to the study and participants were able complete the survey in their own time within a 2-month period. After reading this summary, by clicking 'next', the participants indicated their consent to participate in the study.

Participants answered four sections of the survey developed by researchers. The demographic and BMRQ parts took approximately five to ten minutes. Then the participants were asked to choose one piece of music from three given pieces of classical music, after which they were instructed to listen to the music in three modalities (AV, AO, VO) with a random order. They were asked to report their chills response on a scale from 0 to 10 after each modality. After the participants listened to all three modalities of music excerpt, the fourth section asked about familiarity and liking of the excerpt, and perceived valence and arousal. Finally, they were asked about their thoughts while listening to music. Participants were asked to complete the survey in one sitting and, as a compliance check, a time stamp feature in the survey software recorded the date and time that the survey was commenced and completed. The whole survey took about 20 minutes to complete, and participants who took too long or too short were removed in data analysis.

Participants were able to indicate their desire to be sent a summary of the results at the conclusion of the study. The survey was able to be completed completely anonymous with no identifying data being incorporated.

2.3 Results

2.3.1 Descriptive analysis

According to the scores of BMRQ, participants were divided into three groups: 15 participants were musical anhedonia (scores below 40), 55 were average sensitivity to musical reward (scores from 40 to 60), 12 were high sensitivity group (scores above 60). Mean ratings of participants' familiarity, liking, valence and arousal to music excerpts are showed in Table 2. It is therefore concluded these descriptive statistics that most people liked the songs they heard although they were not familiar with them, and participants rated music pieces as moderately positive and relatively uplifting.

Table 2. Mean Ratings (and Standard Deviations) of music evaluation questions

	Mean ratings (Standard deviations)
Familiarity	3.27 (3.43)
Liking	6.33 (2.29)
Valence	6.55 (2.46)
Arousal	6.08 (2.45)

2.3.2 Inferential statistical analysis

In order to test hypotheses 1 and 2, a two-way ANOVA was conducted to analyse participants' chills response as the dependent variable and Modality (AO, AV, VO) and Sensitivity (low, average, high) as independent variables. Results demonstrated that the main effects of Modality ($F(2, 45.98) = 6.056$, $p = .003$, $\eta^2 = .049$) and Sensitivity ($F(2, 23.58) = 3.106$, $p = 0.047$, $\eta^2 = .026$) were both significant. However there was no significant interaction effect between musical reward sensitivity and music listening modalities ($F(4, 13.80) = 1.818$, $p = .126$, $\eta^2 = .030$). According to the analysis, hypothesis 1 and 2 were not supported.

Table 3. Means and Standard Deviation of chills response under three modalities across musical reward sensitivity

	BMRQ	Mean (SD)	N
AV	high sensitivity	4.333 (3.985)	12
	average sensitivity	2.582 (3.230)	55
	low sensitivity	1.133 (2.134)	15
	Total	2.573 (3.277)	82
AO	high sensitivity	1.916 (3.204)	12
	average sensitivity	2.691 (3.191)	55
	low sensitivity	1.733 (2.631)	15
	Total	2.402 (3.091)	82
VO	high sensitivity	1.750 (3.279)	12
	average sensitivity	.327 (1.375)	55
	low sensitivity	.533 (1.125)	15
	Total	.573 (1.785)	82

2.3.3 Supplementary analysis

However, the data showed a trend towards an interaction effect in the expected direction although there was no significant interaction revealed in the above analysis. Adjacent cut-off points can be less revealing and reliable than using the extreme ends of the scale. Therefore, data about sensitivity was divided at the upper and lower quartiles to investigate if there was an interaction effect between Modality and Sensitivity. Therefore, the upper cut-offs BMRQ score was 55 and the lower cut-offs score was 42. According to these scores, 21 data was selected in high musical reward sensitivity and low musical reward sensitivity groups respectively. The results of a factorial ANOVA using Modality and Sensitivity as independent variables and reported chills as dependent variable suggested that the main effect of Modality was significant ($F(1, 88.048) = 21.450$, $p < .001$), and there was an interaction effect between Modality and Sensitivity ($F(1, 29.762) = 7.251$, $p = .010$). Specifically, post hoc tests suggested that participants' chills response between AV and VO was significantly different.

Table 4. Means and Standard Deviation of chills response under three modalities across musical reward sensitivity

	Sensitivity	Mean (SD)	N
AV	high	4.429 (3.696)	21
	low	1.286 (2.077)	21
	Total	2.857 (3.361)	42
AO	high	2.905 (3.097)	21
	low	1.857 (2.689)	21
	Total	2.381 (2.912)	42
VO	high	1.191 (2.600)	21
	low	.429 (.978)	21
	Total	.810 (1.978)	42

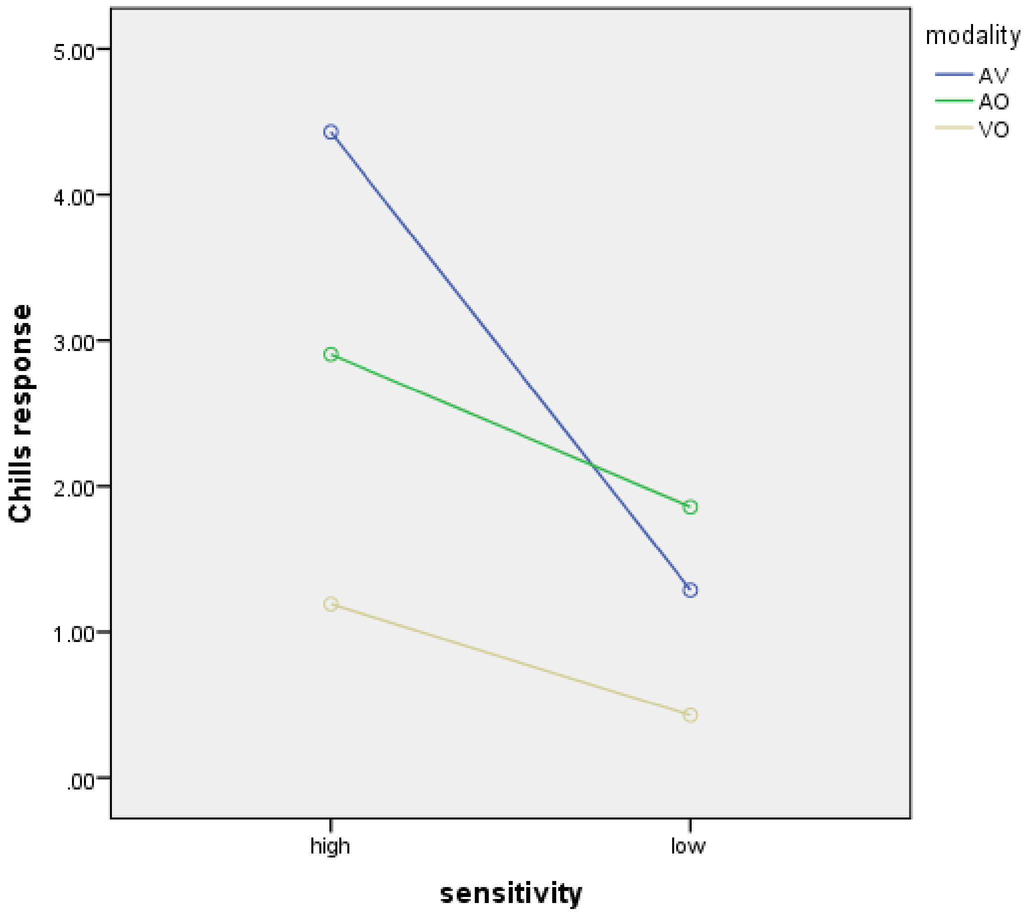

Figure 2. interaction effect between sensitivity and modality

Although there was no hypothesis about music training, an exploratory analysis was conducted below. Additionally, because the difference between Modality and Sensitivity were not as strong as expected, more information was needed to obtain a comprehensive overview of all the potential factors, the effect of music training on listeners' chills response in different listening modalities was analysed. Since there were 29 participants who reported more than 3 years of music training and 35 participants who reported no music training at all, 29 participants with no music training were randomly selected to compare the difference of these two groups. Results of factorial ANOVA with self-reported chills response under three listening modalities as dependent variable and music training as independent variable indicated that the mean chills response of three modalities were statistically significantly different ($F(2, 96.89) = 17.384$, $p <$ .000), but no interaction effect between participants' music training and music listening modalities was presented($F(2, 1.175) = .211$, $p = .81$). Therefore, music training is not associated with participants' chills response across different music presentation modalities.

Furthermore, supplemental analyses were also performed to examine the possible roles of BMRQ scores, familiarity, liking, valence and arousal of the musical pieces in participants' chills response. Linear regression (enter) showed that BMRQ scores and familiarity were two predictors of chills response, $R^2 = .086$, $F(3, 58.213) = 7.140$, $p < .001$. Besides, the effect of familiarity ($\beta = .237$, $t = 3.416$, $p = .001$) was bigger than the effect of BMRQ scores ($\beta = .167$, $t = 2.378$, $p = .018$) on chills response.

Taken together, these results suggested that there is an association between participants' musical reward sensitivity and musical chills response under different listening modalities, further demonstrating that people with high musical reward sensitivity had more chills response in the audio-visual modality compared to audio-only and video-only listening modalities. On the other hand, the low musical reward sensitivity group showed higher scores of chills response in audio-only music presenting than audio-visual and video-only modalities. The other significant result was that musical reward sensitivity and familiarity can predict musical chills response, which means that the more sensitive the listener and the more familiar the music was to participants, the more frequent their chills response.

2.4 Discussion

Overall, the orchestra performance stimuli used in the present study evoked moderately positive emotions with a moderate degree of arousal. Participants' liking for the classical music was moderately positive although most of them were not familiar with these excerpts.

Self-reported chills response revealed significant differences between the audio-visual and audio-only classical music presentation modes among different musical reward sensitivities groups, although both were rated as eliciting more intense emotional responses than the video-only mode. Specifically, participants with high levels of musical reward sensitivity showed more intensive chills response in audio-visual modality than audio-only modality, which was consistent with our hypothesis. However, low musical reward sensitivity group had greater chills response in audio-only than audio-visual modality, which was in contrast to our hypothesis. There are several possible explanations for these results. First, we utilized a within-participants design in which all participants were exposed to all three music listening modalities. We accounted for this potential source of error by randomizing the modalities order, however there is no reliable way of accounting for interindividual variability in musically-induced chills responses – especially in a study conducted on a small sample (Chapados, & Levitin, 2008).

Second, using visual stimuli that consisted of a live orchestra performance could have become a distraction for participants, leaving fewer cognitive resources for them to concentrate on their emotional response. As more expressive cues conveyed via body movements compared to solo performance, especially for listeners who are not familiar with this genre. Furthermore, the participants may be freer to engage in visual imagery in the audio-only presentation mode (in which they faced a black screen) than in the audio-visual mode (Vuoskoski, & Eerola, 2015). Visual imagery is one of the musical emotion-induction mechanisms suggested by Juslin and

Västfjäll (2008), where a listener conjures up—intentionally or unintentionally— visual images while listening to music. Previous laboratory investigations of music-induced emotions have found that musically-induced imagery appears to be a rather common phenomenon (especially when listening to instrumental music; see, e.g., Vuoskoski & Eerola, 2012, 2015). Music-induced imagery has the potential to intensify listeners' emotional responses to music (Vuoskoski & Eerola, 2015). The emotional and expressive cues present in the actual visual component of the AV stimulus may not be as strong or effective in eliciting emotional responses as the potential visual images conjured up by the participants themselves. As one of the participants described her feelings when listening to music, "With the first one, sound only, I was FEELING the music. With the second (audio-visual), I was BECOMING the musicians." It may also be that the participants simply found it more pleasant to immerse themselves in imagery or other kinds of thoughts while listening to music, compared with having to attend to the videoed performance stimulus.

A third possible explanation is related to musical expectancy, another mechanism underlying music-induced emotions, where an emotional response is evoked when a specific feature in the music violates, delays, or confirms the listener's expectations about the continuation of the music (Juslin & Västfjäll, 2008; Meyer, 1956). Unexpected musical events such as sudden changes in texture, tempo, rhythm, or harmony have been associated with musically-induced chills, which are arguably some of the most powerful and pleasurable responses evoked by music (Panksepp, 1995). In a musical performance, some of the performer's movements and gestures may serve to articulate the underlying musical structure, emphasize phrase boundaries, and anticipate emotional changes in the music (MacRitchie, Buck, & Bailey, 2013; Vines, Krumhansl, Wanderley, & Levitin, 2006). Seeing these gestures may make the unfolding musical events more predictable and less surprising to the observer (especially in the case of unfamiliar music), and thus reduce the tension generated by musical expectancies. In other words, it may be that participants found the musical events more “surprising” in the audio-only presentation mode, and more predictable in the audio-visual mode, which could help to explain the higher skin conductance levels recorded in the audio-only mode.

In conclusion, the present study could not reject the null hypothesis that listening to a musical performance through both auditory and visual modalities does not enhance the emotional response compared with the audio-only condition. Contrary to what was hypothesised, audio-visual presentations did not necessarily increase the appreciation of a musical performance as compared with audio-only presentations. With the increase of musical reward sensitivity, participants’ chills response differences in three modalities became more and more apparent. However, what was informative from the present study was that the music stimuli chosen were effective to elicit participants’ chills responses, even when the overall familiarity was low and some participants had never been exposed to this music genre before. In summary, the music stimuli were ideal for lab experiment. Moreover, people with musical anhedonia reported the same chills response in audio-only and audio-visual modality, which illustrated that related visual cues cannot help them appreciate music. Future studies should endeavour to use more varied stimuli—in terms of musical style and emotional expression—and to use both self-report and psychophysiological measures to gain a more reliable account of music-induced emotional responses.

2.5 Chapter summary

In this Chapter, an investigation of a preliminary study about the relationship between musically-induced chills response and music presentation modality, as well as musical reward sensitivity, was conducted by means of an online experiment. BMRQ was used to measure participants' sensitivity to musical reward, and music was presented in three modalities (AV, AO, VO). The overall results concluded a positive answer to research question 1 and 2. Specifically, for high musical reward sensitivity listeners, music congruent visual materials facilitate and increase their degree of chills response whereas these visual information overload average and low musical reward sensitivity individuals in music listening and appreciation process.

Although this preliminary study confirmed our hypotheses, we still need evidence from physiological measurement as an object reflection. Besides, the last research question yet remain to be addressed. Next, Chapter 3 investigates whether different types of visual materials have different impacts on musically-induced chills response. A lab experiment is therefore designed and conducted after this preliminary study through a technique called galvanic skin conductance (GSR). Finally, in Chapter 4 a general discussion and conclusion integrating all chapters is offered.

CHAPTER 3: STUDY 2

The results of the previous preliminary study have confirmed that listeners with different levels of musical reward sensitivity have different chills responses under different music presentation modalities. Nevertheless, the approach that we applied to measure musically-induced chills response is not objective, which may affect the results of the study. In order to further investigate this phenomenon as well as provide some physiological evidence, we designed a second lab experiment to collect participants' skin conductance data. Skin conductance refers to the temporary variation in the electrical resistance of the skin (Hodges, 2010), it is also a reflection of mental activity, usually a result of an affective experience (Venables, 1987). Significant changes in skin conductance in response to music listening have been found to be associated with chills in numerous studies (e.g. Craig, 2005; Grewe et al., 2007; Benedek and Kaernbach, 2011). Hence, it is a feasible and reliable plan to take values of participants' skin conductance as reference to chills reaction.

Furthermore, live music performance is not the only visual resource that is relevant to classical music. Whether different visual materials have different impacts on listeners' chills response is the question that we haven't answered, and therefore needed to be investigated in this study. As discussed in Chapter 2, people with relatively low musical reward sensitivity claimed videos of live orchestra performance to be a distraction for them when listening to classical music. Despite the fact that Juslin and Västfjäll (2008) actually proposed visual imagery as one of the potential mechanisms by which music can induce emotional responses in listeners, they discuss this mechanism in terms of non-musical visual imagery that is conjured up by the music (such as images of nature, for example) rather than performance-related imagery (Juslin & Västfjäll, 2008). We argue that listeners respond to mental images much in the same way as they would to the corresponding stimuli in the “real” world – for example, reacting with positive emotions to a beautiful nature scene, for examples of affective responses to various pictures (Bradley & Lang, 2007). Osborne (1989) reported certain recurrent “themes” in visual imagery to music, such as nature scenes (e.g., sun, sky, ocean) and out-of-body experiences (e.g., floating above the earth), but the results were probably affected by the particular musical style used (“spacey, synthesized electronic music with simple structure, some free form, and much repetition,”). Goldstein noted that common elicitors may be perceived beauty in nature and art. Therefore, it is speculated that relevant natural scenery is another relevant visual material in music listening. As discussed in Chapter 2, some participants claimed videos of live orchestra performance to be intense and distracting. But according to relevant research reviewed above, pictures or visual imagery of natural scenery are less intense but can evoke appreciation to music as well. Therefore, in study 2, we decided to employ audio-visual with natural scenery as the third music presentation modality and excluded visual-only modality, and we hypothesised that low and average musical reward sensitivity listeners would have more chills response in audio-visual with natural scenery than audio-only modality.

3.1 Hypotheses

H1. People with high musical reward sensitivity experience more chills in the audio-visual modality with live performance than in the audio-only modality, and more in audio-only modality than in audio-visual modality with natural scenery.

H2. People with average and low musical reward sensitivity experience more chills in audio-visual modality with natural scenery than in the audio-only modality; more in audio-only modality than in audio-visual with live performance.

3.2 Methods

This was a factorial experiment conducted in the lab designed to compare how different visual materials influence musically-induced chills response in listeners, as well as to measure physiological data of participants' skin conductivity. Galvanic Skin Response (GSR) has been reported a reliable technique of reflecting participants' skin conductivity change towards external stimuli (Bergstrom, Duda, Hawkins, & McGill, 2014). GSR, now more often referred to as electrodermal activity, is a good index of phasic sympathetic activity (Bradley & Lang, 2007). Measured by a psychogalvanometer, usually attached to the fingers and/or palm of the hand, GSR readings indicate changes in skin conductance. An increase in GSR readings indicates a decrease in resistance, which in turn indicates an increase in arousal.

In order to address research question 3 Do different visual materials have different effects on listeners' reaction in emotional peak experience, we employed pictures of natural scenery as another visual material in this study. The main reason for using pictures of natural scenery is that the classical music pieces that we used in our study depicted nature, as indicated by the title of the music pieces. Therefore, relevant natural sceneries are also the sources of congruent stimuli. By comparing two types of visual materials, it can be clearly demonstrated whether different visual inputs, while both congruent, have different impact on listeners' chills response.

3.2.1 Participants

Overall, 59 participants joined our study but 5 were excluded due to missing values of demographic information and BMRQ scores. Therefore, the final sample included 54 participants (38 females, 16 males), mean age 28.37, SD = 8.57, range 18-55 years. About half of the participants (25) had received no professional musical training, while 14 had 1 to 3 years musical training and 15 had more than 3 years training, either instrumental or vocal. On a scale from 1 (not at all important) to 5 (extremely important), participants reported a relatively moderate mean of importance of music in the past 3 years of their lives (mean = 3.43, SD = 1.13, Range:1-5).

3.2.2 Stimuli

The music pieces that we used in this GSR study were the same as what we used in our preliminary study (Table 1). However, the modality of video-only was excluded since there were no self-reported chills elicited in that condition. Instead, we chose another type of visual material – natural scenery, for the related natural scenes expressed by the emotion or the theme of the music. For example, we chose picture of Vltava river for *the Moldau*, picture of Fingal's cave for *Hebrides Overture*, and picture of summer lightning and thunder for *Summer* from Four Seasons (all pictures were downloaded from Google photos, see Appendix B). The music used in all three modalities was extracted from live performance, using several websites to match, trim or download videos (https://imagetovideo.com/; https://ytcutter.com/; https://vubey.yt/download?id=f2c3286f6025f3c1c2050f3588fe773e). Videos of live orchestra performance were the same as those used in the previous study. All excerpts lasted 70 seconds, the same with Study 1.

3.2.3 Measures

Skin conductance was used in this study as an indicator of emotional arousal. The participants' electrodermal activity was measured continuously by an ADInstruments PowerLab 16/35 system. GSR works by detecting the changes in electrical (ionic) activity resulting from changes in sweat gland activity. The electrodes must be sensitive to these changes, and able to transmit that information to the recording device. It is measured by passing a small current through a pair of electrodes (ML116F) attached to the palmer surface of the medial phalanxes of the index and ring fingers on the participants' non-active hand. Gel had been applied on participants' fingers to make the machine capture the signal better. Data was acquired with sampling rates of 1kHz and was measured in units of micro-Siemens (μS) (Figner & Murphy, 2011; Greco, Lanata, Citi, Vanello, Gaetano & Scilingo, 2016). LabChart (v. 8.1.5) software was used to record data, with the recording range set to 40 μS and using initial baseline correction ("subject zeroing") to identify the participants' absolute level of electrodermal activity from all recordings (ADInstruments Inc., Sydney, Australia). The computer programme was run on an acer laptop, which was connected to PowerLab.

Music was played to participants via HP laptop through headphones (Sennheiser HD 280 pro, 64 Ω), and videos were presented on the same laptop. The music player was also connected to Powerlab through an audio box. Self-reported chills responses were measure by a button press box, designed and produced by a technician in MARCS Institute, connected to the PowerLab.

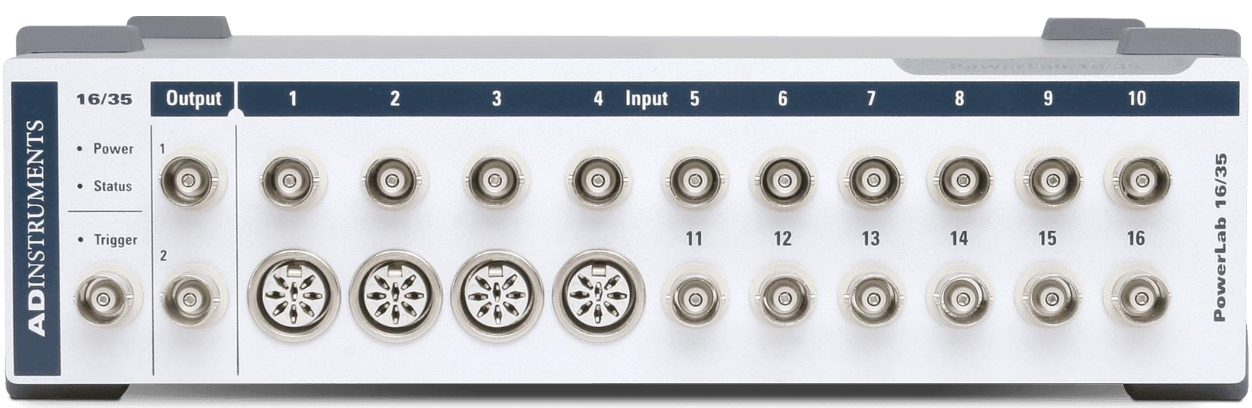

Figure 3. PowerLab 16/35

3.2.4 Procedure

One of the testing room in MARCS Institute was used as the experiment lab, which located in room 45, Ground floor, Building 5, Western Sydney University Bankstown campus. All experiment equipment was set up before participants came to the testing room. To control the environmental factors, room temperature was adjusted.

After welcoming the participants, the experimental process was described and participants signed consent forms to indicate their willingness to participate in the study. Then, participants were asked to answer a questionnaire regarding demographic data (age, gender) and musical experience (as in study 1). This part took 10 minutes to complete. Then, the principles and devices used for physiological measurements were explained, after which they were given a piece of test music to find a comfortable volume for the headphones using an audio box switch. While participants were listening to music, electrodes were attached firmly to their index and ring fingers of the non-active hand, the second phalange. Participants were asked to rest their arms on the table and try not to move their non-active hands, resting for about five to ten minutes before actual testing to allow the signal to stabilize and electrode gel to sink in. All experiments were performed in individual sessions, to guarantee that participants could concentrate on the music, their own feelings, and the rating task.

Participants were instructed to indicate each chill experience by a button press—defined as having a goose-bumps reaction (Gänsehaut) or experiencing shivers (Schauer über den Rücken)—while listening to the music excerpts. They were required to press the button as long as the chill lasts. Participants chose one of three standard classical music excerpts, and listen to all three modalities of this excerpt. The order of the modality presented was randomized. Recording were started in Lab Chart when participants chose the music randomly from the three standard pieces, as the researcher stayed in the same room with participants through the whole experiment. There were three channels used for recordings: Channel 1 was participants' skin conductance response, Channel 2 was music frequency, Channel 3 recorded data from the button press device. Participants followed block instructions to complete the whole listening task.

When participants completed the music listening section, they were helped to take off the electrodes and headphone. After wiping their hands, participants completed the last section - music evaluation. They were asked some questions about their thoughts and emotion changes when listening to music, to ascertain the chills are elicited by the experiment stimuli instead of their memories of past events (see appendix A for whole experiment as Study 1). The whole experiment took about 20 to 40 minutes to complete.

3.2.5 Analysis

Participants' GSR data was separated into two levels by adding digital filter: tonic level (skin conductance level, SCL) and phasic level (skin conductance response, SCR). A low-pass filter of 0.2 Hz and a transition width of 0.4 Hz were set up to define SCL, meanwhile a band-pass of 2 Hz as high cut-off frequency and 1 Hz as low cut-off frequency as smoothing SCR. The slowly varying SCL represents a general trend of physiological arousal, whereas SCR reflects relatively rapid changes in the signal. Using LabChart toolbox Peak Analysis, we extracted peaks in SCR with a threshold of 0.01 μS (Braithwaite, Watson, Jones & Rowe, 2012). However, only the behaviour of button press and detectable SCR peaks happened within a time window of 5s were considered as successful chills response, otherwise it was not defined as musically-induced chills (Grewe, Kopiez & Altenmüller, 2009). The beginning 10s of each excerpt was excluded in order to avoid chills response evoked by the sudden appearance of music, but not evoked by participants' emotional response to music (Sokolov, 1990; Grewe, Katzur, Kopiez & Altenmuller, 2011). Since participants reported different numbers of chills, the average values were calculated of all peaks excerpts for each participant. Results of Peak Analysis of LabChart exported number of SCR peaks, average SCR amplitude, average SCR peak height, and average SCR peak area (see Table 4).

3.3 Results

3.3.1 Preliminary results

According to the BMRQ scores of participants, there were 10 participants in high sensitivity group, 7 in low sensitivity group and 37 in average sensitivity group. Among all the participants, 14 people chose *Hebrides Overture*, 10 chose *Moldau*, 30 chose *Summer*. Results of participants' ratings of the familiarity, liking, valence and arousal of excerpts are shown in the following table (see Table 3). Overall the music selected was relatively unfamiliar to participants and moderate liking, and participants' evaluation was relatively high valence and moderate arousal of selected music pieces.

Table 5. Mean Ratings (and Standard Deviations) of music evaluation questions

	Mean ratings (Standard deviations)
Familiarity	3.57 (3.49)
Liking	5.85 (2.10)
Valence	6.63 (2.10)
Arousal	5.62 (2.43)

As mentioned in the procedure (section 3.2.5), for an event to be categorised as a chills response only two conditions had to be satisfied at the same time: detectable SCR peaks and self-reported chills response as indicated by the button press. Out of the 163 trials recorded (3 trials for each of the 54 participants), 93 trials met this criterion and therefore were retained for the following analyses. In addition, we chose number of SCR peaks, average SCR amplitude and number of button press as three values representing chills response out of five values exported by LabChart Peak Analysis in the following analyses (see Table 4). The number of peaks can indicate ongoing responses to the stimulus and overall levels of background arousal, while peak amplitude was more closely related to the intensity of arousal responses in that a small number of high-amplitude peaks can occur rapidly in an initial response to a stimulus which then decline over time, often known as "task-related activation" (VaezMousavi, Barry, Rushby & Clarke, 2007). And button press represented participants' self-reported chills responses. Although only peaks with button press were included, there may be several peaks occurred within one button press.

Table 6. Means and Standard Deviations of the GSR measures recorded in the three different listening modalities

Measure	Presentation modality		
	Audio-only	Audio-visual 1 (live)	Audio-visual 2 (nature)
Number of SCR peaks	2.390 (3.148)	1.520 (1.913)	1.520 (2.420)
Average SCR amplitude (μS)	0.019 (0.058)	0.025 (0.065)	0.010 (0.022)
Average SCR peak height (μS)	0.012 (0.034)	0.014 (0.034)	0.007 (0.020)
Average SCR peak area (μS)	0.034 (0.089)	0.094 (0.230)	0.053 (0.148)
Number of button press	0.970 (1.197)	1.650 (1.684)	0.900 (1.248)

A validity check was first conducted to test whether SCR is a reliable indicator for chills response, using SCR amplitude as dependent variable and reported chills (button press) as independent measure for each individual. Results proved that there was linear regression between SCR amplitude and participants' self-reported chills, $F(1, 91) = 21.580$, $p < .001$. The equation is SCR amplitude = 0.007+(0.016×self-reported chills). Therefore, SCR amplitude is a reliable value for musically-induced chills response.

3.3.2 Self-reported chills

In order to test H1 and H2, a factorial ANOVA was conducted to analyse participants' self-reported chills response under different Modalities, with BMRQ scores as another independent variable. Although the interaction effect between BMRQ and music listening modalities was significant, $F(42, 640) = 2.301$, $p = .029$), the main effect of Modality was not significant, $F(2, 54) = 2.780$, $p = .089$). However, there was a trend in the expected direction that could suggest the value of doing subsequent T-tests as suggested by the means shown below.

Considering the relatively small group sample sizes, a paired T-test with number of button press as the dependent variable separately, and Modality as an independent group factor was conducted in all three musical reward sensitivity groups. Outcomes showed that in high sensitivity group, participants' self-reported chills were significantly different between live performance and nature scenery video listening modalities ($p = .022$), which indicated that high musical reward sensitivity listeners reported significantly more chills reaction in music with live performance than music with natural scenery (Figure 4). In sum, part of H1 was supported while H2 was not support in self-reported chills indicator.

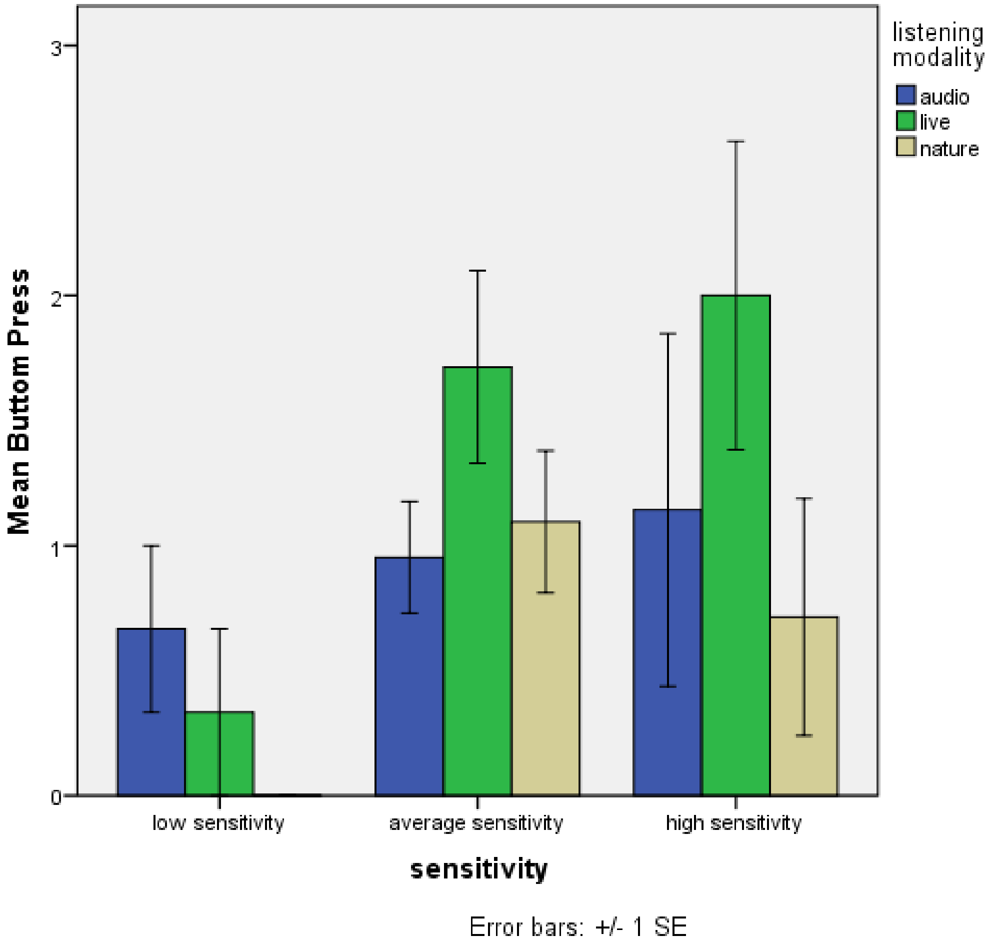

Figure 4. Means of number of button press under three modalities across musical reward sensitivity

3.3.3 SCR analysis

In order to test H1 and H2 in physiological indicators, a two-way MANOVA was used to test two dependent variables (number of SCR peaks, SCR amplitude) for differences between Modality (audio-only, audio with live performance, audio with natural scenery) across participants defined by their musical reward sensitivity (low, average, high). The main effect of Modality was significant ($F(10, 162) = 2.432$, $p = .010$, $\eta^2 = .131$) whereas the main effect of Sensitivity ($F(10, 162) = 1.818$, $p = .061$, $\eta^2 = .101$) was not, and no interaction effect was illustrated ($F(20, 332) = 1.338$, $p = .152$, $\eta^2 = .075$). Furthermore, the effect of Modality to number of SCR peaks (F = 3.249, p = .044, η^2 = 0.072) was significant but not to SCR amplitude (F = .631, p = .535, η^2 = .015). Pairwise comparisons indicated that differences of number of SCR peaks between audio-only and audio with live performance (p = .042), as well as between audio-only and audio with natural scenery (p = .023) were statistically significant, whereas the difference of number of SCR peaks between audio with live performance and audio with natural scenery was not significant (p = .798). These results suggested that the overall number of SCR peaks were statistically significantly more in audio-only music listening modality than in audio-visual with live performance modality, as well as than in audio-visual with natural scenery modality.

Considering of the relatively small group sample sizes, a paired T-test with number of SCR peaks and SCR peak amplitudes as the dependent variable separately, and Modality as an independent group factor was conducted in all musical reward sensitivity groups. Outcomes showed that in low sensitivity group, participants' numbers of peaks had a significant difference in audio-only and nature scenery video listening modality (p = .038), which suggested that low musical reward sensitivity listeners had significantly more frequent physiological arousal in audio-only music listening modality than music with natural scenery. This was in contrast to H2. In sum, H1 and H2 were not supported in SCR indicators.

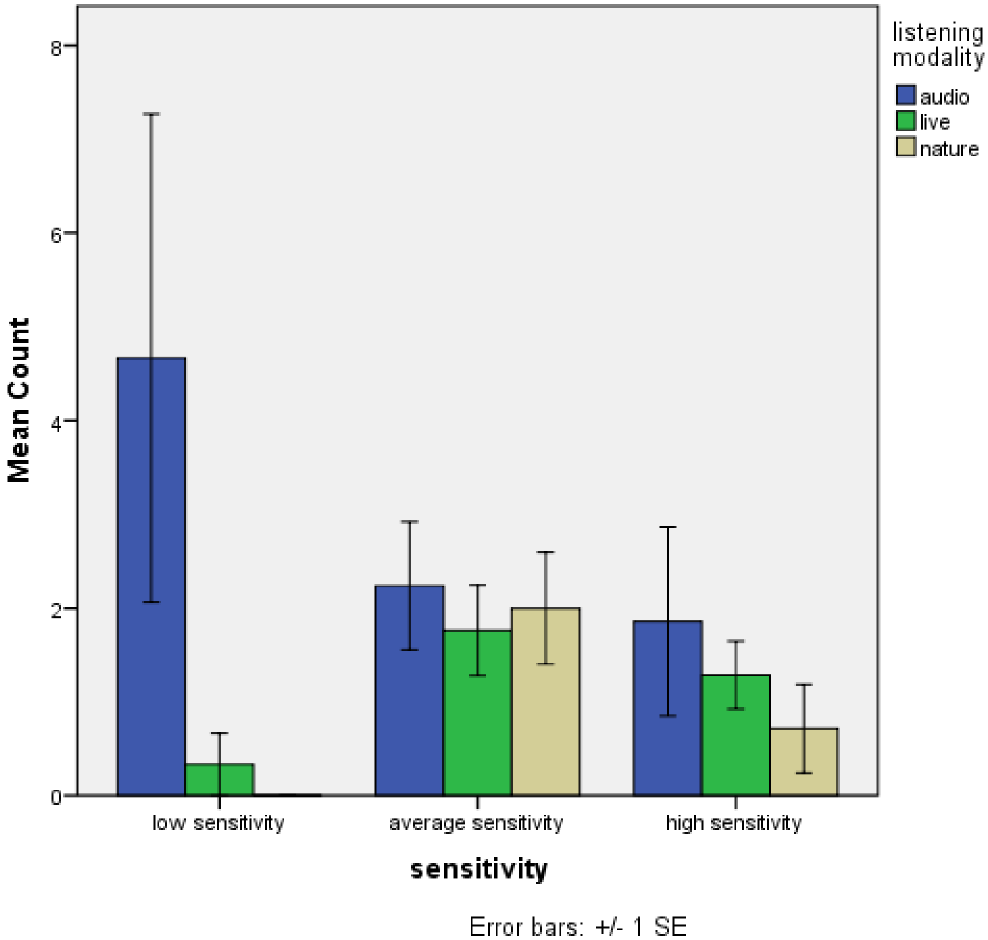

Figure 5. Means of number of SCR peaks under three modalities across musical reward sensitivity

3.3.4 Supplementary analysis

Different statistical techniques were employed in order to fully explore physiological data and the relationship between physiological data and psychological data (BMRQ, music training, familiarity, liking, valence, arousal).

To examine the contribution of each subfactor of BMRQ while controlling for the remaining subfactors, we included all five BMRQ subfactors as predictors in a linear regression performed on number of SCR peaks, SCR amplitude and number of button press. Outcomes demonstrated that no factors contributed to numbers of SCR peaks; Social was the only facet of

BMRQ whose unique variance was related to SCR amplitude, β = .211, *t* = 2.588, *p* = .011, and the overall modal was significant, R^2 = .034, *F*(1, 92) = 4.250, *p* = .042; Emotion Evocation significantly contributed to numbers of button press (R^2 = .082, *F*(1, 92) = 3.967, *p* = .049), and the contribution of Emotion Evocation was β = .204, *t* = 4.037, *p* = .049 to participants' self-reported chills response.

To obtain a more comprehensive outlook of potential musical reward sensitivity differences, correlations were conducted between each of the five subfactors of BMRQ to uncover any other possible correlations with numbers of SCR peaks, SCR amplitude and numbers of button press. Social was significantly correlated with SCR amplitude (*r* = .211, *p* = .021); Music Seeking (*r* = .177, *p* = .045) and Emotion Evocation (*r* = .204, *p* = .025) had significantly positive correlations with numbers of button press.

In addition, supplemental analyses were also performed to examine the possible roles of music training, familiarity, liking, valence and arousal of the musical pieces in the experience of chills response. Pearson correlation analysis was conducted on familiarity, liking, valence and arousal scores with number of SCR peaks, SCR amplitude and number of button press. Valence and SCR amplitude had a significantly negative correlation, *r* = -.256, *p* = .013; Participants' self-reported chills (button press) had significantly positive correlations with all four variables: familiarity (*r* = .307, *p* = .003), liking (*r* = .263, *p* = .011), valence (*r* = .339, *p* = .001), arousal (*r* = .249, *p* = .016). Kendall correlation was conducted on music training with numbers of SCR peaks, SCR amplitude and number of button press. Only number of button press was significantly positively correlated with music training, *r* = .213, *p* = .016.

Additionally, a linear regression analysis was conducted to examine the relationship between music training, familiarity, liking, valence, arousal and self-reported chills response (button press). The results indicated that valence and arousal were two predictors of individual's self-reported chills response, $F(2, 85) = 8.895$, $p < .001$. Besides, the effect of valence ($\beta = .322$, $p = .001$) was bigger than the effect of arousal ($\beta = .225$, $p = .022$) on reported chills.

3.4 Discussion

Taken together, only the results from participants' self-reported chills reaction supported part of H1 that high musical reward sensitivity listeners showed more chills response in audio-visual with live performance than in audio-visual with natural scenery. In other words, music with live performance was the most successful chills inducer for high musical reward sensitivity people. Unexpectedly, low musical reward sensitivity listeners had more chills response in audio-only modality than audio-visual listening modalities. However, no significant difference was found in average musical reward sensitivity listeners.

The classical music with natural scenery appeared to be the least chills induced presentation modality. According to participants' answers in the last open-end question "Do you think you had different feelings under different listening modalities? If so, what made you have different feelings?", we concluded that natural scenery tends to be "relaxing", "calming" or comforting although two participants mentioned it helped them appreciate the beauty of nature and thought provoking. The pictures we chose reflect the theme endowed by composers, but it does not necessarily have to be every listener's understanding of the music. This may explain why low musical reward sensitivity participants had more chills response in audio-only than in audio-visual with natural scenery modality. On the contrary, videos of orchestra performance claimed to be impressive, enjoyable, exciting, uplifting, increasing the intensity and thrilling. These are all the qualities related to the intense emotional feelings. Meanwhile, for the listeners prefer audio-only modality, they like to “create my own images”, “use my imagination to paint my own scene of emotion”.

From the results of overall chills inducing situation, we could summarise that only half of music listening trials collected from participants evoked chills response. The main reason is that we used existed classical music despite their testified efficacy in previous studies, but only compared to other experimental stimuli which are not as optimal as participants’ own music. Many studies asked participants to bring their own chills-inducing music piece and it turned out that familiarity is a strong influencing factor of musically-induced chills response. This reason also leads to small sample sizes in this study and failed to conclude the same results as found in preliminary study.

Interestingly, the subfactors of BMRQ contributed to the musically-induced chills response although no main effect was found between the overall BMRQ score and chills. Social Reward can predict SCR amplitude, with further explaining is that the more likely the individual is willing to share with music, the more SCR amplitude he or she has. This derives from the social functions of music. Music can enhance social bonds and promote social contacts, such as attending music concert, dancing, cultural events and ensemble. Through sharing music experience and preference, individual obtains rewarding pleasure and increases social attraction. Emotion Evocation represents the capability of music in evoking emotions, and it proved to be an important factor to self-reported chills response from our analyses. Recent studies suggest that the hedonic impact of music listening is driven by its intrinsic ability to evoke emotions (Salimpoor et al., 2009, 2011). There is general agreement that music is capable of inducing a significant emotional impact in humans (Gabrielsson, 2001, 2010; Juslin & Va¨stfja¨ll, 2008; Sloboda, 1992, 2010; Wells & Hakanen, 1991) and individual differences in this factor might explain to a certain degree the differences observed on the amount of pleasure experienced in music. However, this effect might also be influenced (although not necessarily) by the ability to perceive and decode emotions from music fragments (Gabrielsson & Juslin, 2003; see Juslin & Va¨stfja¨ll, 2008).

Another interesting result was that valence and arousal of the music pieces that we chose can predict the perceived musical chills response by listeners themselves, which means that the more positive and the more intense the music is, the more chills will be elicited. However, participants' chills amplitudes had a negative correlation with valence, indicating that negative emotion music can elicit greater chills amplitude yet positive emotion music can elicit more peaks. Although previous research indicated controversial results about the relationship between valence and chills. Almost all research agree that intense emotional response to music is associated with high arousal (Rickard, 2004;). Besides, Huron (2006) illustrated that the delight from the chills stems from a contrast between a "fast track" response (the reaction/prediction response) mediated by subcortical structures in the brain, which is substituted by a "slow track" response (the appraisal response) mediated through cortical structures (LeDoux, 1989). The fast response to the surprise is quick and has a negative valence whereas the slow appraisal responses follow quickly thereafter and tend to have a neural or positive valence, resulting in an overall positive feeling of pleasure. Therefore, the present study proposes that it is feasible for further studies to explore the relationship between self-report chills, SCR amplitude, and valence respectively.

3.5 Chapter summary

Comparing to the first study that we did, this study focused on the physiological measures of participants' musically-induced chills responses. Findings showed that SCR was a reliable variable reflecting participants' chills responses and consistent with self-reported chills. However, skin conductance is a highly distinct variable varies from person to person and numerous emotional change can elicit the change of SCR level. General speaking, this study failed to support our hypotheses.

Due to the limit time of conducting this study, we only collected a rather small sample size, especially for low and high sensitivity participants to musical reward. This is also the main reason why the results of this GSR study is discrepant with the results of our preliminary study. Second limitation of this study lies in the experimental design. A within-subject experimental design was used in order to avoid the error by the differences between participants and to detect differences across levels of independent variables. However, the disadvantage of doing this is bringing the effect of presentation order, which has a huge impact on participants' chills response. Both previous research and our study confirmed that familiarity was a crucial factor to musically-induced chills, thus the first version participants listened to was less familiar than the second and third version, no matter which presentation modality they were.

To conclude, the present GSR study results in a positive answer to research question three and four. However, the distinction across musical reward sensitivity groups was not statistically significant. Future studies with larger sample size are expected in order to investigate this phenomenon.

CHAPTER 4: GENERAL DISCUSSION

4.1 Thesis summary

The overall aim of this thesis was to explore how the congruent visual inputs affect individual's musically-induced chills response by splitting participants into different musical reward sensitivity groups. Furthermore, both physiological and self-report measures were used in order to comprehensively reflect participants' chills responses. To address these goals, the following specific questions were brought forward:

1. Do related visual resources have an impact on chills responses evoked by music? And if so,

   1.A. Do they facilitate and increase the degree of chills response?

   1.B. Do they overload music listening and appreciation process?

2. Do people with different levels of musical reward sensitivity experience different levels of chills in response to visual, auditory or visual-auditory stimuli?
3. Do different visual materials have different effects on reactions to emotional peak experience?

The present thesis examined these proposed questions using western classical music as auditory stimuli and live orchestra performance and music-related natural sceneries as visual stimuli. Participants were recruited across relatively broad age groups and divided by their score of BMRQ. The preliminary study was designed as an online self-report survey in order to test if the selected music pieces can induce chills response successfully, as well as to collect some initial results (Chapter 2). According to the results of our first study, video-only listening modality was excluded and pictures of musical theme related natural sceneries were used as a second visual resources in audio-visual presenting modality (Chapter 3). In addition, the second study was conducted as a lab experiment via measuring participants' skin conductance (Chapter 3).

Findings in Chapter 2 confirmed our predictions that high musical reward sensitivity group showed more and greater chills response in audio-visual presenting modality comparing to audio-only modality, whereas average and low musical reward sensitivity groups elicited more chills response by audio-only listening modality than audio-visual modality although the difference was not significant.

In Chapter 3, no difference was found in average musical reward sensitivity group under three music presentation modalities. Low musical reward sensitivity listeners had significantly more frequent arousal in audio-only music listening modality than music with natural scenery; and high musical reward sensitivity listeners reported significantly more chills reaction in music with live performance than music with natural scenery.

4.2 General discussion and future research

This is the first empirical study using videos of live orchestra performance as visual stimuli in the cross-modal aesthetic chills response research. In the previous studies, some chose to let participants bring their own chills music, while others used recordings of invited solo musician performance. By applying the recordings of live performance, it is closer to live music listening situation which helps us better understand the role of visual inputs in emotional perception in audience. There is a possible explanation and widely agreed by researchers about why music can evoke chills response: musical expectancy. Surprise often indicates a biological failure to predict a future event, and thus the chill effect is directly linked to musical expectation.

Most music theoreticians consider musical anticipation as one of the principal means by which music conveys musical meaning and emotion.

In this present project we have confirmed that individual's sensitivity to musical reward affects his or her music appreciation modality across sensory domains. As the involvement of reward system, it is also noteworthy to the benefit of the intensely pleasurable that music brings (Blood & Zatorre, 2001). The pleasure of music is a specific phenomenon in human species (McDermott & Hauser, 2007), As for the possible explanation of why listeners vary in musical reward sensitivity have different response under multi-modal music listening situations, it may derive from cognitive load. Activity was elevated in brain areas known to be involved in attention. High resonance visual information can improve attention level for high sensitivity people. However, it appears to be overload for low and average people, especially unfamiliar music pieces. Konecˇni assumed that the underlying psychological mechanism is aesthetic awe (Konecˇni, 2005).

Another interesting yet remaining to be confirmed theory proposed by Blood and Zatorre is whether the reward system is involved in musical performance rather than listening. Until now, research has mainly been concentrating on emotions involved in music listening but is performing music different from listening to music? In other words, why do musicians play? One possible explanation may be the euphoria that many musicians report to experience occasionally when they play and which is an important motivational factor possibly linked both to the music and to social factors (Berliner, 1994; Monson, 1997). In a preliminary questionnaire investigation, 111 out of 129 Danish conservatory students enrolled in programs designed to make them professional musicians reported to be "feeling high" when playing music. It seems to be a plausible hypothesis that the reward system and dopamine is involved also when musicians play. Therefore, it is also reasonable to speculate that listeners' reward system can be evoked by watching musicians' performance because of emotional contagion. Emotional contagion refers, in relation to music, to the process in which listeners internally mimic the emotional expression of music, thereby reproducing the emotion felt by performers. This explanation has been observed relevant to facial expressions, where expressed emotions such as fear and anger activate facial muscles in the observer (Lundqvist, 1995).

Accordingly, music listening has been shown to induce a premotor response (Koelsch et al., 2006), which has been hypothesised to reflect an auditory mirror-neuron system at work (Iacoboni et al., 2005; Rizzolatti and Craighero, 2004), such that the emotions of the listener correlates with the expressed emotions in the music, be it in vocal or instrumental music. Admittedly, there is not much evidence to support the existence of this mechanism and the knowledge about the associated brain systems is very sparse, apart from the possible involvement of premotor and mirror systems. However, it can help to explain various phenomena related to music psychology such as the strong identification between musical fans and their musical heroes. And future research can pay attention to this question.

In sum, it is noteworthy for future studies to look at the effect of individual differences in optimal arousal levels and how this relates to the relative impact of adding visual stimuli.

4.3 Limitations

Since individual's musical reward sensitivity obeys the rule of normal contribution, it is obvious that one intrinsic overall limitation of this research is small sample sizes of high and low musical reward sensitivity group. Another limitation to be considered is the lack of neuroimaging evidence support. Although researchers have tried to mended this gap through PET and fMRI (as discussed in chaptered 3), other brain scanning modalities with better time resolution such as MEG would seem better suited to uncover the relationship between the hedonic valence and music since emotional responses to music is not stable in listeners during listening or even across several instances of listening to a music piece.

In the present work, we focused on the dynamic nature of emotional responses to music. The way GSR varies as a function of time is complex and variable. An important related aspect to be taken into consideration in the following discussion is the latency of GSR, which refers to the onset of the physiological response. It usually ranges from one to four seconds for GSR following the presentation of emotion-evoking stimuli (such as familiar faces (Ellis &Lewis, 2001) and acoustic stimulation (Elie & Guiheneuc, 1990). This is also the latency of GSR following a musical event (Krumhansl, 1996; Sloboda & Lehmann, 2001). Therefore, we estimate the musical stimuli presented in our studies to activate physiological responses with a similar time course. Much less is known about the temporal dynamics of latency, that is, whether it is consistent or it varies over time. A better understanding of the dynamics of GSR latency would help determine the temporal relationship between GSR and subjective tension and between skin conductance responses and their underlying events in the musical stimuli.

The dominance of the auditory signal over the visual in music performance as shown by SCR amplitude might have different explanations. One possible explanation, as pointed out by Vines et al. (2006), is that the making of music requires a specific coupling between the performer and the instrument. The necessity to maintain this perfect coupling limits the movements that the musician can convey, and consequently the complexity of information delivered by the music sound (e.g. pitch, intensity, rhythm and so on, for review see Juslin & Sloboda, 2001) cannot often be expressed with body movements. However, some instruments limit body movements more than others. For example, the clarinettists in Vines et al. (2006), as well as the saxophonist in Petrini, McAleer & Pollick, (2010) had more limited arm movements when compared, for example, with drummers and pianists. These researchers suggested that it would be informative to compare instruments with different restrictions upon movements of the body to examine whether, when the movements for the musician are less restricted, they are able to deliver the same emotional content as that evoked by the sound.

Another limitation to the current project with highlighting is use of orchestra classical music as auditory stimuli and live orchestra performance as visual stimuli, which turns out to be an exploratory method for investigating cross-modal interaction in chills responses. As discussed above, most research used solo musician's performance. Furthermore, we failed to control the effect of familiarity to the experimental stimuli. In the future studies, musical improvisation is an ideal material instead of pre-existing pieces of music to make sure that participants share the same level of familiarity with the music stimuli, and that the elicited emotional states in participants will be due to the music displays and not to memories linked to familiar pieces of music.

4.4 Implications

Music has become an inseparable part of human's life. Music-related topic can increase public engagement with research as well as promote public awareness and understanding of the origins and early evolution of life from a new perspective. Since the original function of chills was to adjust body temperature and send signals when in danger. How it developed to conclude cognitive component is an exciting question for strong emotions. This research will contribute to a deeper understanding of the impact of visual stimuli on response to auditory input. This information is important both because of the potential for music and multi-sensory stimuli to be used for therapeutic effects, and because of interest in boosting dwindling numbers of attendance at live music performance.

Implications in music therapy and medical use, visual imagery is wildly used for its relation in inducing emotions resembling the emotions attached to the images itself. Research has shown that peak experiences in music, particularly in early childhood, have long-lasting effects on the likelihood of engagement with music (Sloboda, 2005). It seems to require no special context and no specific musical training or expertise. Therefore, the present project will be able to provide theoretical support in music education and music therapy.

In an age where at-home auditory and visual conditions are so advanced, the meaning of the existence of live performances seems vague. In order to understand why people experience greater pleasures attending live performances and to boost live audience attendance, the need to understand what contributes to the audience experience in live settings becomes essential. Previous researches about the audience's response to live concert focus on personal interactions. Thompson (2006) asked a concert audience to rate their experience, enjoyment and emotional response to the performance. Their enjoyment of the event was better predicted by their own degree of emotional engagement than the perceived quality of the performance. A recent study demonstrated that for live music concert-goers, their brain waves synchronize (Grahn, 2018). On the other hand, researchers gave empirical support to the impact of the shape of hall for classical music or symphony live performance (Patynen, Tervo, Robinson, & Lokki, 2014). They used nonlinear physical-mathematical model to analyse interactions between the concert-hall acoustics and listeners' hearing and found out that rectangular shaped concert-hall geometry had stronger binaural reflect, therefore enhanced musical dynamics. However, researchers seemed neglect the importance of visual components in music listening. Thus, we expect to contribute to this research field.

Another notably implication is the use of moving music in ads. A group of Netherland researchers (Strick, de Bruin, de Ruiter, & Jonkers, 2015) conducted three experiments among 372 university students to investigate the persuasive power of moving music (i.e., intensely emotional and chills-evoking music) in audio-visual advertising. In Experiment 1, moving music increased transportation and some behavioural intentions (e.g., to donate money). Experiment 2 experimentally increased the salience of manipulative intent of the advertiser and showed that moving music reduces inferences of manipulative intent, leading in turn to increased behavioural intentions. Experiment 3 tested boundary effects and showed that moving music fails to increase behavioural intentions when the salience of manipulative intent is either extremely high (which precludes transportation) or extremely low (which precludes reduction of inferences of manipulative intent). Moving music did not increase memory performance, beliefs, and explicit attitudes, suggesting that the influence is affect-based rather cognition-based. Together, these studies illustrate that moving music reduces inferences of manipulation and increases behavioural intentions by transporting viewers into the story of the ad.

4.5 Conclusion

In sum, findings from this thesis indicate that listeners experience different extent of chills response under different presentation modalities across sensory domains. Second, this variance is defined by the musical reward sensitivity of listeners. Several studies have demonstrated that chills have psychological as well as physiological correlates (Craig, 2005; Guhn et al., 2007; Rickard, 2004). This information made chills even more interesting as a parameter; no other known indicator of emotions combines a strong, positive, subjective feeling, and a measurable physiological arousal response in one reaction.

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APPENDIX A: FULL VERSION OF PRELIMINARY ONLINE STUDY

Start of Block: Demographic Questions

This survey is part of a study being conducted by current Master of Research student from Western Sydney University. The aim of the study is to identify people's experience when listening to music. Your participation in this study will help us learn how to understand this better.

The survey will take about 20 minutes to complete. You will be asked to answer some questions about your musical preference and sensitivity and to listen to two pieces of music. We think you will enjoy doing this, but there is some chance that answering the questions or listening to the music could lower your mood or cause some distress. If that happens you are free to stop doing the survey. Participation is voluntary and you can withdraw from the study at any time before submitting your responses by simply closing your browser window. If the music triggers any negative emotions, resources for obtaining help are offered at the end of the survey.

Your answers will be completely anonymous. You will not be asked to enter your name or other details that will make you personally identifiable unless you wish to. The information we collect in this study may be published in academic journals or at conferences, however, you will not be identified in any such publication. If requested by you (and if you provide contact details) we will provide you with a summary of the results of this study. Five years after the study has been completed all data will be destroyed.
If you have further questions about the study at any stage please feel free to email Sylvia at the MARCS Institute for Brain, Behaviour & Development at Western Sydney University on 19239880@student.westernsydney.edu.au

The study has been approved by the University of Western Sydney Human Research Ethics Committee. The Approval number is...
If you have any complaints or reservations about the ethical conduct of this research you may contact the Ethics Committee through the Office of Research Services on +61 2 4736 0229, Fax +61 2 4736 0013 or email humanethics@westernsydney.edu.au. Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.

By clicking 'Next' you indicate your understanding and consent to the above.

What is your gender?

- ○ Female (1)
- ○ Male (2)
- ○ Other (3)

How old are you?

- ○ 18 to 25 (3)
- ○ 26 to 35 (4)
- ○ 36 to 55 (5)
- ○ 56 to 65 (6)
- ○ 66 or over (7) ____

Please indicate your highest level of education completed.

- ○ Grammar School (1)
- ○ High School or equivalent (2)
- ○ Vocational/Technical School (2 year) (3)
- ○ Some College (4)
- ○ College Graduate (4 year) (5)
- ○ Master's Degree (MS) (6)
- ○ Doctoral Degree (PhD) (7)
- ○ Professional Degree (MD, JD, etc.) (8)
- ○ Other (9)

End of Block: Demographic Questions

Start of Block: Musical education and preference

Number of years of instrumental or vocal music lessons, either private or group within the past 5 years

- ○ 0 (1)
- ○ 1 (2)
- ○ 2 (3)
- ○ 3 (4)
- ○ more than 3 (5)

How important has music been in your life in the past 3 years?

- Not at all important (1)
- Slightly important (2)
- Moderately important (3)
- Very important (4)
- Extremely important (5)

On the average, how many hours per day do you actually spend listening to music, either while doing something else or as your main activity?

- 0 (1)
- 1-2 (2)
- 3-4 (3)
- 5-8 (4)
- 9 or more (5)

How many musical events (concerts, recitals, clubs etc., of all types) have you attended in the past 12 months?

○ 0 (1)

○ 1-3 (2)

○ 4-6 (3)

○ 7-9 (4)

○ 10 or more (5)

End of Block: Musical education and preference

Start of Block: Musical sensitivity

Please choose the best options that suit your feeling for each statement.

	Completely disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Completely agree (5)
When I share music with someone I feel a special connection with that person. (1)	○	○	○	○	○
In my free time I hardly listen to music. (2)	○	○	○	○	○
I like listen to music that contains emotion. (3)	○	○	○	○	○
Music keeps me company when I'm alone. (4)	○	○	○	○	○
I don't like to dance, not even with music I like. (5)	○	○	○	○	○
Music makes me bond with other people. (6)	○	○	○	○	○
I inform myself about music I like. (7)	○	○	○	○	○
I get emotional listening to certain pieces of music. (8)	○	○	○	○	○
Music calms and relaxes me. (9)	○	○	○	○	○
Music often makes me dance. (10)	○	○	○	○	○
I'm always looking for new music. (11)	○	○	○	○	○

I can become tearful or cry when I listen to a melody that I like very much. (12)	○	○	○	○	○
I like to sing or play an instrument with other people. (13)	○	○	○	○	○
Music helps me chill out. (14)	○	○	○	○	○
I can't help humming or singing along to music that I like. (15)	○	○	○	○	○
At a concert I feel connected to the performers and the audience. (16)	○	○	○	○	○
I spend quite a bit of money on music and related items. (17)	○	○	○	○	○
I sometimes feel chills when I hear a melody that I like. (18)	○	○	○	○	○
Music comforts me. (19)	○	○	○	○	○
When I hear a tune I like a lot I can't help tapping or moving to its beat. (20)	○	○	○	○	○

Page Break

End of Block: Musical sensitivity

Start of Block: Block 3

Please choose one of the three following pieces of music to listen to and indicate the type/ brand of earphone that you are going to use.

○ “The Moldau”—Bedrˇich Smetana (1)

○ Piano Concerto No. 5, Op. 73 (3. movement)—Ludwig v. Beethoven (4)

○ “Hebrides Overture”, Op. 26—Felix Mendelssohn (5)

○ earphone (6) ____

Page Break

End of Block: Block 3

Start of Block: Block 4

Please listen to the music you selected as well as watch the following two videos in the given order.

- ☐ http://spotify:track:6WZ6HWu6dzyfUZvuRkcSrh (1)
- ☐ (2)
- ☐ (3)

Page Break

Did the music and videos work well?

○ Yes (1)

○ No (3)

Did you experience any chills (goosebumps or shivers down the spine) when listening to this music?

○ Yes (1)

○ No (2)

Display This Question:

If Did you experience any chills (goosebumps or shivers down the spine) when listening to this music? = 1

If so, please rate how strong the chills were that you experienced on a scale of 0 (very weak) to 10 (very strong).

	0	1	2	3	4	5	6	7	8	9	10
chill experience ()											

End of Block: Block 4

Start of Block: Block 5

Please listen to the music you selected as well as watch the following two videos in the given order.

- ▢ http://spotify:track:2MyzMXNwYohmjxehjnuOpM (1)
- ▢ (2)
- ▢ (3)

Page Break

Did the music and videos work well?

- Yes (1)
- No (3)

Did you experience any chills (goosebumps or shivers down the spine) when listening to this music?

- Yes (1)
- No (2)

Display This Question:

If Did you experience any chills (goosebumps or shivers down the spine) when listening to this music? = 1

If so, please rate how strong the chills were that you experienced on a scale of 0 (very weak) to 10 (very strong).

	0	1	2	3	4	5	6	7	8	9	10
chill experience ()											

End of Block: Block 5

Start of Block: Block 6

Please listen to the music you selected as well as watch the following two videos in the given order.

- ☐ http://spotify:track:3Zk0dR7yM2s3sSqShMDNMy (1)
- ☐ (2)
- ☐ (6)

Page Break

Did the music and videos work well?

◯ Yes (1)

◯ No (3)

Did you experience any chills (goosebumps or shivers down the spine) when listening to this music?

◯ Yes (1)

◯ No (2)

Display This Question:

If Did you experience any chills (goosebumps or shivers down the spine) when listening to this music? = 1

If so, please rate how strong the chills were that you experienced on a scale of 0 (very weak) to 10 (very strong).

	0	1	2	3	4	5	6	7	8	9	10
chill experience ()											

End of Block: Block 6

Start of Block: Block 7

Please respond to the following questions on a scale of 0 to 10.

0 1 2 3 4 5 6 7 8 9 10

How familiar are you with this piece of music? (from very unfamiliar to very familiar) ()	
How much do you like this piece of music? ()	
Did the music induce negative or positive feelings? (from negative to positive) ()	
How much did the music make you feel more awake or alert? ()	

What were you thinking when listening to music?

End of Block: Block 7

Start of Block: Block 8

If you experienced any psychological distress from listening to music or doing the survey, here are some contact details of 24-hour support.

NSW Mental Health Line: 1800 011 511Lifeline: 131 114Suicide Call Back Service: 1300 659 467 HealthDirect Australia: 1800 022 22224 hour line for international students: 1800 735 807

You can leave your email address if you want a summary of the results of this study.

____

End of Block: Block 8

APPENDIX B: EXPERIMENTAL MATERIALS

Natural scenery pictures