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Jonna Katariina Vuoskoski

Emotions Represented and Induced by Music

The Role of Individual Differences

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ABSTRACT

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The primary aim of this work was to investigate how listener attributes such as personality, empathy, and mood contribute to different emotional phenomena in the context of music. Predictions arising from personality and emotion theories were applied to music-related emotional phenomena, and tested using methods of experimental psychology. The emotional phenomena under investigation were perceived emotions, felt emotions, and preference for music expressing different emotions. A related aim was to systematically compare the applicability of different emotion models in the measurement of emotions expressed and induced by music. The work comprises five publications, each investigating a different aspect of the main aims. The findings suggest that personality, mood, and empathy contribute notably to individual differences in music-related emotional phenomena. Temporary mood was reliably associated with mood-congruent biases in ratings of perceived emotions, while personality traits correlated with preference ratings for music excerpts expressing different emotions. In the case of music-induced emotions, both mood and personality were associated with the intensity of emotional responses evoked by different types of excerpts, whereas trait empathy contributed to the susceptibility to music-induced sadness. Regarding the results of the emotion model comparisons, it is concluded that the dimensional model of affect may provide the most coherent and reliable ratings in studies where varied musical stimuli are used. Implications for future studies are raised concerning the significance of individual differences in musical contexts, as well as the selection of an appropriate emotion model for the study of emotions represented and induced by music.

Keywords: Music-induced emotion, preference, personality, empathy, mood, emotion models.

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LIST OF PUBLICATIONS

List of the publications (reprinted after the introductory part) included in this thesis:

I Eerola, T., & Vuoskoski, J. K. (2011). A comparison of the discrete and dimensional models of emotion in music. *Psychology of Music, 39*, 18-49.

II Vuoskoski, J. K., & Eerola, T. (2011). The role of mood and personality in the perception of emotions represented by music. *Cortex*, *47*, 1099-1106.

III Vuoskoski, J. K., & Eerola, T. (2011). Measuring music-induced emotion: A comparison of emotion models, personality biases, and intensity of experiences. *Musicae Scientiae, 15*, 159-173.

IV Vuoskoski, J. K., Thompson, W. F., McIlwain, D., & Eerola, T. (2012). Who enjoys listening to sad music and why? *Music Perception, 29,* 311-317.

V Vuoskoski, J. K., & Eerola, T. (2012). Can sad music really make you sad? Indirect measures of affective states induced by music and autobiographical memories. *Psychology of Aesthetics, Creativity, and the Arts.* DOI: 10.1037/a0026937.

SUMMARY OF PUBLICATIONS

I The first publication aimed to compare the applicability of discrete emotions and dimensional emotion models in the measurement of perceived emotions in music. A related aim was to introduce and validate a new set of unfamiliar film music excerpts conveying a range of emotions. Linear mapping techniques between the discrete and dimensional models revealed a high correspondence along two central dimensions that can be labeled as valence and arousal. The major difference between the discrete and dimensional models was that the discrete model was weaker in characterizing emotionally ambiguous examples.

The author was responsible for the data collection, and a part of the data analysis and writing.

II The primary aim of the second publication was to explore how listeners' personality traits and mood states are reflected in their evaluations of discrete emotions represented by music. A related aim was to investigate the role of personality in preference ratings for excerpts expressing different emotions. A subset of data from the first publication was used in the analyses. Current mood was associated with mood-congruent biases in the evaluation of perceived emotions, but extraversion moderated the degree of mood-congruence. Personality traits were also associated with preference ratings.

The author was responsible for the major part of the work, including data collection, data analysis, and writing.

III The third publication compared the applicability of music-specific and general emotion models in the assessment of music-induced emotions. A related aim was to explore the role of personality and mood in music-induced emotions. The dimensional model outperformed the other two models in the discrimination of music excerpts, and principal component analysis revealed that 89.9% of the variance in the mean ratings of all three models was accounted for by two principal components that could be interpreted as valence and arousal. Personality-related differences were the most pronounced in the case of the discrete emotion model.

The author carried out the major part of the work, including experimental design, data collection, writing, and most of the data analyses.

IV The fourth publication addressed the paradoxical enjoyment of sad music by investigating what kinds of subjective emotional experiences are induced in listeners by sad music, and whether the tendency to enjoy sad music is associated with particular personality traits. The data collected in Study 3 were used in the analyses. Although sadness was the most salient emotion experienced (in response to sad excerpts), other, more positive and complex emotions such as nostalgia, peacefulness, and wonder were clearly evident. The personality traits *Openness to Experience* and empathy were associated with liking for sad music, suggesting that aesthetic appreciation and empathetic engagement play a role in the enjoyment of sad music.

The author carried out the central part of the work, including experimental design, data collection, data analysis, and most of the writing.

V The aim of the fifth publication was to investigate whether sad music can induce genuine sadness in listeners. A related aim was to explore how certain mechanisms of music-induced emotions are involved in the induction of sadness. Participants were randomly assigned into four conditions with different tasks: listening to unfamiliar sad or neutral music, or to self-selected sadness-inducing music, or recalling a sad autobiographical event and writing about it. The effectiveness of the emotion induction was determined using two indirect measures of affective states: a word recall task, and a picture judgment task. The results indicate that music can indeed induce varying levels of genuine sadness in the listener. However, this effect is to some extent dependent on the music's relevance to the listener, as well as on the empathic tendencies of the listener. The results also suggest that somewhat different mechanisms are involved in emotions induced by familiar and unfamiliar music.

The author was responsible for the major part of the work, including experimental design, data collection, data analysis, and writing.

CONTENTS

1 INTRODUCTION

Music and its emotional effects play an increasingly important role in our daily lives, as portable music listening devices have become something of a necessity. It has been estimated that music affects our emotions and feelings approximately 55–64% of the time we spend listening to it (Juslin & Laukka, 2004; Juslin et al., 2008). This represents quite a significant part of our lives as we spend 37%–41% of our waking time listening to music, either passively or actively (Juslin et al., 2008; Sloboda et al, 2001). Music can induce a range of emotions in listeners – both positive and negative (see e.g., Juslin & Laukka, 2004), and many people use music listening as a deliberate method of mood regulation (Saarikallio & Erkkilä, 2007). The powerful emotional effects of music have also been harnessed by music therapy, for example, which has successfully been used in the treatment of clinical depression (Erkkilä et al., 2011).

Although much evidence of the emotional effects of music has been accumulated, some aspects of the emotion-induction process remain unclear. Different people react differently to a given piece of music, and even the same person reacts differently in different situations. A good illustration of the individual differences in emotional responses to music features the paradoxical enjoyment of sad music: Some listeners get enormous enjoyment out of profound music-induced sadness, while others cannot stand listening to sad music (see e.g., Huron, 2011; Garrido & Schubert, 2011). Perhaps there is something in common in the personalities of people who react similarly to certain types of music? Although it was suggested already a decade ago that music-induced emotions emerge from the interplay of the music, the listener, and the situation (e.g., Scherer & Zentner, 2001; Gabrielsson, 2001), little is known of the personality factors that contribute to the emotional responses of listeners (see e.g., Juslin, 2009).

Studies from other fields have shown that individual differences are an inherent part of emotional processes (for a review, see Rusting, 1998). For example, the personality trait *Extraversion* (for definition, see section 3.1 of this work) has been associated with a susceptibility to positive emotions and moods, while *Neuroticism* has been associated with a susceptibility to negative emotions and moods (e.g., Larsen & Ketelaar, 1991; Rusting & Larsen, 1997). Furthermore, temporary moods have been shown to bias the perception of emotional stimuli such as pictures and facial expressions (e.g., Isen & Shalker, 1982; Bouhuys et al., 1995). Although music as a stimulus has been neglected in studies investigating individual differences in emotional processing, it is suggested in this work that it holds a lot of potential for future research. In comparison to many other types of emotional stimuli (such as facial expressions, for example), music is more versatile: In addition to effectively communicating the expression of emotion, music can also induce strong emotional responses in listeners, including liking and disliking responses. This would enable the simultaneous study of multiple emotional phenomena.

A few studies have investigated the role of personality traits in music-induced emotions in an explorative manner (e.g., Kallinen & Ravaja, 2006; Juslin et al., 2008; Ladinig & Schellenberg, 2011), but there has been a lack of systematic testing of the theoretical predictions that arise from personality theory. One potentially significant trait that has been almost entirely neglected is empathy (for definition, see section 3.2). Trait empathy may contribute to the intensity of music-induced emotions, as emotional contagion – a subcomponent of empathy – may be one of the mechanisms through which music induces emotions in listeners (Juslin & Västfjäll, 2008). However, empirical investigation is required to evaluate this hypothetical link.

Another issue that has not yet been decisively settled concerns the type(s) of emotion model(s) that would be the most applicable for the study of emotions represented and induced by music. Most previous studies on music and emotion have utilized emotion models that have been developed in other fields (such as the basic emotion model and the circumplex model; see Zentner & Eerola, 2010), although there is evidence that these models may not be compatible with the actual emotions that are expressed and induced by music (Juslin & Laukka, 2004; Zentner et al., 2008). Although some preliminary comparisons between music-specific (e.g., the Geneva Emotional Music Scale; Zentner et al, 2008) and general emotion models have already been carried out (Zentner et al., 2008), this issue warrants further investigation due to the limitations of the materials used.

This work aims to investigate how listener attributes such as personality, empathy, and mood contribute to the perception of emotions expressed by music, and to the emotional responses that are induced by music. A related aim is to systematically compare the applicability of different emotion models in the measurement of emotions expressed and induced by music. Uncovering the personality factors that contribute to individual differences in music-mediated emotions will help us understand why different people prefer different kinds of music, and why different people perceive a given piece of music differently. The contributing personality factors are also of significance for neuroimaging studies investigating the processing of music in the brain, as emotional stimuli have been shown to activate different areas in the brains of people with different personalities (Canli et al., 2002). The field of music and emotion research would also greatly benefit from a theoretical consensus regarding the most appropriate emotion model(s), as the rating scales provided in listening experiments determine the types of self-ratings listeners can give.

This work is positioned in the multidisciplinary field of music psychology, and it uses methods of experimental psychology to investigate the proposed research questions. This work will investigate predictions that arise from personality and emotion theories, and test their applicability in music-related emotional phenomena. The results of this work will contribute not only to the study of music and emotions, but also to the study of individual differences in emotional processes in general. This work also aims for ecological validity – as far as it can be achieved in a laboratory environment – by using musical stimuli that would be stylistically familiar to most participants (yet free from episodic memories), and – in some occasions – by allowing participants to bring their own music to the experiment.

The next three chapters (Chapters 2-4) will provide the theoretical background of the work, including definitions of different emotional phenomena, descriptions of how certain individual difference variables contribute to emotional processes in general, and an overview of previous studies on music and emotions. Chapters 5-7 will introduce the aims, methods, and results of the work. Details of these are provided in the original research articles I-V, reprinted after the introductory part. Chapter 8 will present the conclusions and implications of the work.

2 EMOTION

2.1 Definition of emotion

Emotions are arguably an important part of human functioning, although emotion researchers cannot agree on what exactly is considered an emotion, and what is not (see e.g., Russell & Barrett, 1999). One proposed set of emotion components (Scherer, 2000; 2005) include *cognitive appraisal* (i.e., an individual's assessment of the personal significance and implications of events or current circumstances), *bodily reactions* (especially those generated by the autonomic nervous system), *action tendencies* (adaptive actions such as interrupting ongoing behavior and generating new goals or plans), *motor expression* (e.g., facial and vocal expression of emotion), and *subjective feeling* (i.e., the subjective experience of an emotion, which has monitoring and regulating functions). In addition, emotions are often accompanied by changes in information processing and judgment (see e.g., Bower, 1981; 1991; Lerner & Keltner, 2000). These components are assumed to be synchronized (in an emotion episode) and driven by *cognitive appraisal* (Scherer, 2005). However, the appraisal-based emotion theories have been criticized for their reliance on cognitive processing, as there is evidence that emotional reactions can also be generated "automatically" by untransformed sensory input (Zajonc, 1980; 1984; Öhman, 2008) and empathy (e.g., Hoffman, 2008). Nevertheless, a consensus is emerging that emotions are complex, multicomponent episodes that generate a readiness to act (e.g., Nolen-Hoeksema et al., 2009).

In this work, emotion is measured using self-ratings of subjective feeling, and by assessing emotion-related biases in memory (see e.g., Bower, 1981; 1991) and judgment (see e.g., Lerner & Keltner, 2000). The components and mechanisms associated with music-induced emotions are presented and discussed in section 4.1.

2.1.1 Emotion vs. mood

Mood and emotion are closely related affective phenomena. The subjective feeling associated with a mood may sometimes be very similar to the subjective feeling of an emotion, which can make the distinction between the two difficult (Beedie, Terry, & Lane, 2005). Even affect researchers have sometimes used the two terms interchangeably, as there is a lack of empirical evidence regarding the proposed emotion-mood distinctions (Beedie, Terry, & Lane, 2005). Russell and Barrett (1999) distinguish "prototypical emotion episodes" from "core affect". They define "prototypical emotion episodes" as the clearest cases of emotions (such as being frightened by a dangerous animal) that have a specific object. "Core affect", on the other hand, refers to elementary yet consciously accessible affective feelings that are not necessarily directed at anything, such as feeling sadness after listening to sad music. Russell and Barrett (1999) also postulate that "core affect" is literally at the core of all emotion episodes – prototypical and non-prototypical – while moods are defined as prolonged core affect without a clear object (Russell & Barrett, 1999).

Beedie, Terry, and Lane (2005) asked academics and non-academics to describe what they believed to be the difference between emotion and mood. Of non-academics, 65% mentioned *cause* as a distinction between emotion and mood (i.e., emotions have a clear cause, while moods do not), 40% mentioned *duration* (i.e., moods last longer than emotions), and 25% mentioned *control* (i.e., emotions cannot be controlled, while moods can be regulated). The academics proposed similar distinctions: 62% mentioned *duration*, 41% mentioned *intentionality* (i.e., an emotion is usually aimed at something or someone, while a mood is not), and 31% mentioned *cause*. Although certain distinctions between emotion and mood appear to be rather consistent over "everyday" and scientific notions, there remains a conceptual issue: It is still unclear whether emotions and moods are two distinct phenomena, or whether they actually represent the opposite ends of a single continuum (Beedie, Terry, & Lane, 2005). The present work adopts the view that clear distinctions cannot be made between emotions and moods, as affective processing may be better described as a continuous process (see e.g., Sloboda & Juslin, 2010).

2.1.2 Affective states and emotional processing

As already mentioned earlier in this chapter, affective states such as emotions and moods can alter the processing of emotional stimuli (see e.g., Bower, 1981; 1991; Lerner & Keltner, 2000). According to the associative network theory of affect (Bower, 1981), affective states bias the perception and interpretation of emotional material in affect-congruent directions. The theory also asserts that people remember more easily material (such as words or memories) that is affectively congruent with their current affective state. Previous studies have provided evidence that induced affective states do in fact lead to affect-congruent judgment biases: Bouhuys et al. (1995) discovered that induced depressed mood influenced the perception of drawn faces with prototypical and ambiguous emotional expressions. When feeling more depressed, the participants perceived more sadness and rejection in ambiguous faces, and less happiness and invitation in prototypical faces. Similarly, Isen and Shalker (1982) found that induced negative mood was associated with lower pleasantness ratings for pleasant, ambiguous, and unpleasant slides, while induced positive mood was associated with higher pleasantness ratings.

However, the empirical evidence regarding the effects of affective state on memory is somewhat inconsistent: Previous studies have reported affect-congruent memory effects, no memory effects, and affect-incongruent memory effects (for reviews, see Matt, Vásquez, & Campbell, 1992; Rusting, 1998). For example, Rinck, Glowalla, and Schneider (1992) found that mood-congruent memory effects were present when the recalled words were strongly valenced (i.e., sad participants remembered more unpleasant words), but the effect was reversed in the case of mildly valenced words (i.e., sad participants remembered more pleasant words). Isen (1985) has suggested that affect-incongruent memory effects stem from participants' instinctive attempts to regulate their moods and emotions. In fact, Parrott and Sabini (1990) demonstrated in a series of experiments that affect-incongruent memory effects emerge in naturalistic conditions where participants are unaware of the relevance of their affective states to the experiment. In contrast, affect-congruent memory effects were observed when the participants were instructed to deliberately change their moods, thus possibly inhibiting their mood-regulation tendencies.

Musical stimuli have rarely been used to investigate affect-related memory and judgment biases. However, the few exceptions are discussed in section 4.3 (which deals with individual differences in the context of music and emotions). Furthermore, the aforementioned memory and judgment biases can be used as relatively reliable (indirect) measures of experienced affect (for a review, see Västfjäll, 2010), as they are free from problems associated with demand characteristics and the conscious interpretation of internal processes (see Västfjäll, 2010). These indirect measures of experienced affect are also utilized in the present work (for details, see section 6.1.3).

2.2 Discrete and dimensional approaches

There are two competing notions regarding the underlying structure of emotions: the discrete and the dimensional approach. The discrete approach asserts that there are a limited number of "basic emotions" such as anger, fear, happiness, sadness, disgust, and surprise that are innate and universal, and have evolutionary significance (see e.g., Ekman, 1992). According to this view, each basic emotion has an independent, underlying neural system, and can be associated with specific facial and vocal expressions and physiological reactions. Conversely, the dimensional approach presumes that all emotional and affective states can be explained in terms of core affect dimensions such as valence (pleasure-displeasure) and arousal (awake-tired), that have independent, underlying neurophysiological systems (Russell, 1980; Posner, Russell, & Peterson, 2005). From the dimensional perspective, discrete emotions are just points in the dimensional space. Different researchers have suggested different dimensions (and different combinations of dimensions), but the most well-known formulation is arguably the affective circumplex (comprising the dimensions of valence and arousal; Russell, 1980). Other formulations include the multidimensional model of activation (tense arousal and energetic arousal; Thayer, 1989), and the three-dimensional model of affect (valence, energetic arousal, and tense arousal; Schimmack & Grob, 2000).

Both approaches have been criticized for a lack of reliable empirical evidence. For example, evidence from neuroimaging studies does not seem to support the notion that there would be a specialized neural pathway for each basic emotion (for a review, see Barrett & Wager, 2006), while the proponents of the discrete approach argue that the pattern of autonomic nervous system responses associated with emotions is not compatible with the dimensional view (e.g., Levenson, 2003). Despite the discrepancies between the two approaches, there have been attempts to combine these views. For example, the Conceptual Act Model (see e.g., Barrett, 2006) proposes that when people undergo emotional episodes, they utilize conceptual knowledge about emotions to categorize the experienced core affect – in order to make sense of it. This process is assumed to be very similar to colour perception, because we also perceive different wavelengths of light as discrete colours.

The discrete and dimensional approaches have been commonly applied in music and emotion studies (e.g., Zentner & Eerola, 2010), albeit some of the "basic emotions" that are rarely expressed or induced by music (such as disgust; see e.g., Juslin & Laukka, 2004) have often been replaced with more appropriate emotion categories such as peacefulness (e.g., Vieillard et al., 2008) or tenderness (e.g., Gabrielsson & Juslin, 1996). Some researchers have even argued that neither the dimensional nor the discrete approach sufficiently captures the richness of the emotional responses induced by music, and have proposed music-specific emotion models such as the Geneva Emotional Music Scale (GEMS; Zentner et al., 2008). The GEMS, for example, consists of 9 factors that are labelled *wonder, transcendence, power, tenderness, nostalgia, peacefulness, joyful activation, sadness,* and *tension*. The types of emotional responses induced by music are discussed in more detail in Chapter 4.1. In this work, multiple emotion models – the discrete, the three-dimensional, and the GEMS – are utilized in the data collection, as this will allow the critical evaluation and comparison of the different models.

3 INDIVIDUAL DIFFERENCES AND EMOTION

"Individual differences" is a broad concept that refers to a host of dimensions or variables that differ between individuals. Such variables are, for example, personality, motivation, trait empathy, and self-esteem. In the case of emotions and emotional processing, individual differences are the rule rather than the exception (see e.g., Reisenzein & Weber, 2009; DeYoung & Gray, 2009; Rusting 1998), and thus it is not surprising that emotions are inherent in the trait theory of personality. For example, traits such as *Neuroticism* and *Extraversion* are characterized by negative and positive emotionality, respectively (e.g. Reisenzein & Weber, 2009). Furthermore, personality traits have been shown to influence emotional processing, biasing attention, judgment, and memory in trait-congruent directions (for a review, see Rusting, 1998). The following chapters will introduce and define the different variables that contribute to emotion-related differences, and summarize previous findings regarding trait-congruent processing.

3.1 Personality

Personality traits – understood as dispositions to behave in a particular way in a range of situations – are one way of describing, conceptualizing, and measuring individual differences in human functioning (e.g., Pervin, 2003). Hundreds of trait descriptors such as shy, friendly, or generous are used in everyday language to characterize a person's personality. These types of everyday trait words have been used as the basis for constructing broader personality factors (e.g., Allport & Odbert, 1936; Cattell, 1943; McCrae & Costa, 1987). Different types of traits and trait structures have been suggested throughout the 20th century (e.g., Cattell, 1956; Eysenck, 1947; Eysenck & Eysenck, 1975), and during the recent decades, a consensus has emerged regarding the Five-Factor Model of personality (also known as the *Big Five*, see e.g., John & Srivastava, 1999). The *Big Five* is also the trait structure adopted in the present work. The five-factor structure of personality has been validated across cultures (e.g., McCrae & Costa, 1997), and it has been estimated that 51% to 58% of the variation in the five traits is of genetic origin (Loehlin et al., 1998). However, the model's atheoretical, lexical origins may be seen as a weakness (see e.g., Deary, 2009).

The *Big Five* personality dimensions are labelled *Extraversion, Neuroticism, Agreeableness, Conscientiousness,* and *Openness to Experience* (see e.g., John & Srivastava). Of these, all but the trait *Conscientiousness* are related to emotion dispositions (e.g., Reisenzein & Weber, 2009; John & Srivastava, 1999). *Extraversion* can be defined as a tendency to be outgoing, sociable, assertive, energetic, and enthusiastic (John & Srivastava, 1999). *Neuroticism,* on the other hand, is viewed as the tendency to experience negative emotions such as anxiety, worry, and tension, and to be moody and emotionally unstable (John & Srivastava, 1999). *Extraversion* is commonly associated with positive emotionality, and *Neuroticism* with negative emotionality (e.g., Derryberry & Reed, 2003). People scoring high in *Extraversion* have been found to be more susceptible to positive mood manipulation, while high *Neuroticism* scorers are more susceptible to negative mood manipulation (Larsen & Ketelaar, 1991; Rusting & Larsen, 1997). *Extraversion* and *Neuroticism* have also been associated with the *Behavioural Approach System* (BAS) and the *Behavioural Inhibition System* (BIS; see e.g., Pickering & Gray, 1999), respectively, which can be described as two functional systems that respond to cues of reward and potential threat (DeYoung & Gray, 2009). *Extraversion* and *Neuroticism* have also been connected with individual differences in brain function: *Neuroticism* has been associated with heightened brain activity (at rest and in response to negative stimuli) in brain regions associated with negative affect, whereas *Extraversion* has been associated with brain activity (at rest and in response to positive stimuli) in brain regions that are important for reward and approach behavior (for a review, see DeYoung and Gray, 2009)

Agreeableness is a prosocial trait related to kindness, tender-mindedness, trust, and modesty (John & Srivastava, 1999). *Agreeableness* has previously been associated with the tendency to be more empathic (Del Barrio, Alija, & García, 2004), and with the motivation to control negative emotions in communication situations (Tobin et al., 2000). People scoring high in *Agreeableness* have also been shown to be less anger-prone, as the trait is negatively correlated with trait anger (Kuppens, 2005). *Conscientiousness* is associated with task- and goal-directed behavior such as planning and organizing, and highly conscientious people can be characterized as dependable, thorough, and efficient. However, no links have been established between *Conscientiousness* and emotional dispositions (e.g., Reisenzein & Weber, 2009). Finally, *Openness to Experience* can be defined as the tendency to be imaginative and curious, to have wide interests, and to appreciate arts and aesthetic experiences (John & Srivastava, 1999). Indeed, people scoring high on *Openness to Experience* tend to be more sensitive to aesthetic emotions, as they experience more "chills" or "shivers down the spine" in response to aesthetic stimuli such as music (McCrae, 2007; Nusbaum & Silvia, 2011). It has also been found that people scoring high on *Openness to Experience* (in particular the facet *Openness to Feelings*; Costa & McCrae, 1992) tend to experience a wider range of emotions than those scoring low (Terracciano et al., 2003).

Studies that have investigated the contribution of the *Big Five* personality traits to music-induced emotions will be discussed in section 4.3.

3.2 Trait-congruent processing

Besides being associated with stable emotion dispositions, certain personality traits have also been associated with trait-congruent biases in emotion-related memory, judgment, perception, and attention (for a review, see Rusting, 1998). As mentioned in Section 2.1.2, affective states such as emotions and moods are also associated with biases in emotional processing. However, Rusting (1998) postulates that personality traits and affective states contribute to different types of emotional processing. Personality traits are mainly associated with self-referential emotional processing, while affective states contribute to more cognitive emotional processing (such as the perception of facial expressions; Rusting 1998). The key aspect of self-reference is that the self acts as a setting against which incoming data are interpreted (see e.g., Rogers et al., 1977). Rusting's (1998) assertion is supported by the findings of Martin et al. (1983), who found that people scoring high on *Neuroticism* recalled more negative (than positive) information about themselves, but not about others. Furthermore, this effect was not related to depressed mood. Similarly, Zelenski and Larsen (2002) found that *Extraversion* and *Neuroticism* biased participant's self-referential judgments in trait-congruent directions, and these personality effects were also not mediated by mood states. *Extraversion* predicted increased likelihood judgments for positive future events, while *Neuroticism* predicted increased likelihood judgments for negative events.

According to Rusting (1998), personality traits associated with emotional dispositions – such as *Extraversion* and *Neuroticism* – may also alter the processing of emotional cues in the presence of a negative or a positive affective state. For instance, *Extraversion* is associated with the tendency to avoid negative stimuli (and to focus on positive stimuli) when experiencing negative mood states, and thus it should also moderate the extent to which negative mood-congruency effects emerge. In contrast, individuals scoring high in *Neuroticism* should be especially susceptible to negative mood-congruent thoughts. This assertion is supported by the findings of Richards et al. (1992), who reported that the effect of induced state anxiety on performance on the emotional Stroop task was modulated by the participants' trait anxiety. Participants with high trait anxiety had an attentional bias towards stimuli that were congruent with their (induced) mood, while participants scoring low in trait anxiety had a tendency in the opposite direction. Similarly, a study by Rusting (1999) demonstrated that positive mood-congruence was stronger for participants scoring high in positive affectivity, while *Neuroticism* and negative affectivity moderated the mood-congruence effect for negative emotions. However, these effects were only present after mood had been manipulated. The assumed relationships between personality traits, affective states, and cognitive and self-referential emotional processing are visualized in Figure 1.

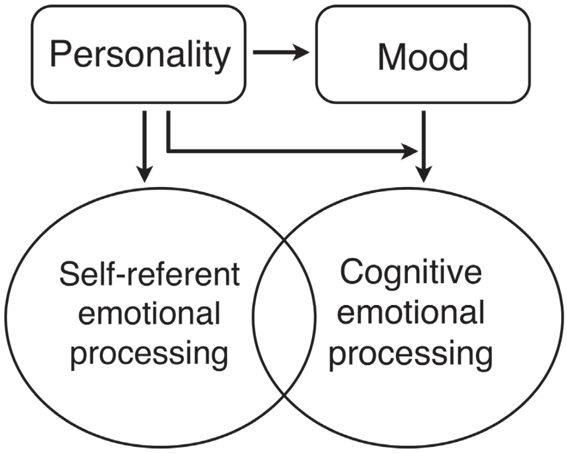

FIGURE 1 The assumed relationships between personality traits, mood, and cognitive and self-referential emotional processing (after Rusting, 1998).

3.3 Empathy

In its broadest sense, trait empathy can be defined as an individual's responsiveness to the observed experiences of others, involving both perspective-taking capabilities or tendencies, and emotional reactivity (Davis, 1980). Davis (1980) has suggested that trait empathy is a multidimensional construct that comprises four components: *Perspective-taking, Fantasy, Empathic Concern,* and *Personal Distress*. The *Perspective-taking* and *Fantasy* components tap into the more cognitive aspects of empathy. *Perspective-taking* can be understood as the tendency or the ability to shift perspectives (i.e., to see and understand things from another's point of view), while *Fantasy* can be defined as the tendency to identify oneself with fictional characters in books and films (Davis, 1980). In contrast, the *Empathic Concern* and *Personal Distress* components deal with the more emotional side of empathy. *Empathic Concern* taps into the tendency to experience feelings of compassion and concern for observed individuals, whereas the *Personal Distress* component is associated with the individual's own feelings of fear, apprehension and discomfort in response to the negative experiences of others (Davis, 1980).

Some empirical studies have addressed the role of empathy in emotional responses, and the findings suggest that positive and negative emotional responses may be differently associated with cognitive and emotional empathy.

Davis et al. (1987) discovered that emotional empathy was associated with experienced negative emotions (in response to negative film excerpts), while cognitive empathy was associated with positive emotional reactions (Davis et al., 1987). Levenson and Ruef (1992) found that a physiological linkage (i.e., similar patterns of autonomic responses) between the subject and the observed target increased the accuracy in which the subject perceived the emotions experienced by the target. However, this effect was only observed in the case of negative emotions. Thus, it seems that emotional empathy is associated with the reactivity to observed negative emotions in particular. Interestingly, the experience of empathic distress while watching a tragic film has been associated with greater enjoyment of tragic films, suggesting that there may exist a link between empathy and the enjoyment of fictional tragedy (De Wied et al., 1994). However, it is not yet known what the mechanisms behind such enjoyment are, although the portrayal of more positive themes such as friendship, love, and human perseverance – often present in tragic films – have been proposed as one potential source (De Wied et al., 1994).

The concept of empathy as an individual difference measure is of particular interest for the present work, as it has been suggested that empathy and emotional contagion may contribute to music-induced emotions (e.g., Scherer & Zentner, 2001; Juslin & Västfjäll, 2008). Trait empathy has previously been linked with emotional contagion in general (Doherty, 1997), but empirical evidence is lacking regarding the role of trait empathy in music-induced emotions. It may be speculated that the empathy-subcomponents such as *Fantasy* and *Empathic Concern* may contribute to the emotional responsiveness to music, and – as in the case of tragic films - they may also play a role in the enjoyment of sad music.

4 MUSIC AND EMOTION

Music and emotion is a broad topic that covers a wide variety of research questions, perspectives, and approaches. The communication of emotion via music could be investigated from the point of view of the composer, the performer, or the listener, for example. A lion's share of the studies investigating music and emotion – including the present work – has studied the topic from the listeners' point of view (see e.g., Juslin & Sloboda, 2010). There are at least three different types of affective phenomena associated with music listening. Firstly, music can represent or "express" emotions that can be perceived and recognized by listeners. Secondly, music also has the ability to induce emotional responses in listeners, or – in other words – somehow affect or alter their emotional states. Thirdly, one can either like or dislike a piece of music. Scherer and Zentner (2001) and Gabrielsson (2001), among others, have postulated that music-induced emotions emerge from the interplay of the music, the listener, and the situation. The following chapters describe the different music-related affective phenomena in detail, and address the roles of musical features, listener attributes (such as personality), and situational factors in these phenomena.

4.1 Perceived and felt emotion

An important distinction in the study of music and emotions is the type of emotion under investigation – perceived or felt. In the context of music, the term "perceived emotion" refers to emotions that are somehow represented, communicated, or "expressed" by music, and consequently perceived and interpreted by the listener. The term "felt emotion", on the other hand, refers to emotional reactions that music induces in the listener.

Although it is generally accepted that music is able to represent or express emotions, there has been some controversy over whether music can also induce actual emotions in listeners (see e.g., Konečni, 2008). Kivy (1990) characterized the opposing sides of this debate as musical "cognitivists" and "emotivists".

Musical cognitivists, including Kivy himself, assert that a musical piece can be described as "sad" because the musical features of the piece express sadness. Musical emotivists, on the other hand, claim that when listeners call a piece of music "sad", it is because the piece makes them sad. According to Kivy (1989), if a listener claims to be saddened by music (and if this sadness is not due to sad memories or extra-musical associations), he or she must be mistaken. Kivy asserts that music cannot evoke the "garden variety" of emotions (such as sadness, happiness, or fear) in listeners because music lacks the real-life consequences that are required to trigger these emotions.

However, the current, dominant view in the field of music and emotion research maintains that emotion perception and emotion induction can take place simultaneously, although emotion perception does not always lead to emotion induction (see e.g., Gabrielsson, 2002). In reality, the border between felt and perceived emotion may be blurred, and the relationship between the two somewhat complicated. In other words, a musical piece expressing happiness may not necessarily induce happiness in the listener; it may not induce any emotional response whatsoever, it can induce some other type of emotion (see e.g., Gabrielsson, 2002), or it can induce mixed emotions (see e.g., Hunter, Schellenberg, & Schimmack, 2007). The relationship between perceived and felt emotion also depends on the mechanism through which a particular piece of music induces an emotional response (see section 4.1.1).

Previous studies on perceived emotions have mainly investigated the degree to which listeners agree on the emotional expression of music, and which musical features contribute to the perception of certain emotions (see e.g., Gabrielsson, 2002). The perceived emotional expression of music is influenced by both structural features of the music (i.e., the composition), and the expressive efforts of the performer (e.g., Gabrielsson & Lindström, 2001). Although some of these features (and their emotional associations) are culturally learned, there exists also evidence suggesting that music can effectively communicate emotions across cultures (e.g., Balkwill & Thompson, 1999; Fritz et al., 2009).

Although most music and emotion researchers agree that music can at least *move* the listener emotionally, there is disagreement over what emotions music can actually induce, and whether music-induced emotions are comparable to "real-life" emotions (see e.g., Konečni, 2008; Juslin & Västfjäll, 2008). Despite this disagreement, studies investigating the subjective feelings associated with music-induced emotions have usually applied general emotion models – such as the basic emotion model (e.g., Ekman, 1992) or the two-dimensional circumplex model (Russell, 1980) – to the domain of music (for a review, see Zentner & Eerola, 2010). Some researchers have also attempted to construct music-specific emotion models, such as the Geneva Emotional Music Scale (GEMS; Zentner et al., 2008), but it still remains to be concluded which emotion model(s) are the most applicable to the measurement of music-induced emotions.

Mounting evidence suggests that music-induced emotions are associated with similar manifestations as emotions experienced in other contexts, including physiological reactions (e.g., Krumhansl, 1997; Lundqvist et al., 2009), emotional expression (e.g., Lundqvist et al., 2009; Witvliet & Vrana, 2007), brain activation (e.g., Sammler et al., 2007; Schmidt & Trainor, 2001), and cognitive changes (e.g., Clark & Teasdale, 1985; Parrott & Sabini, 1990). Although music listening is sometimes used as a method of "mood-manipulation" in other fields of research, Juslin and Västfjäll (2008) argue that the affective responses evoked by music are better characterized as emotions rather than moods, since the listeners' responses are focused on an object (the music), their duration is relatively short (ca. 5-40 minutes; for a review of musical mood-induction studies, see Västfjäll, 2002), and they involve components that are commonly associated with emotions rather than moods.

4.1.1 The emotion-induction mechanisms of music

If music can indeed induce genuine emotions in listeners, what are the mechanisms that make emotion induction via music possible? Juslin and Västfjäll (2008; see also Juslin et al., 2010) have suggested six mechanisms through which music may induce emotions in listeners: *Brain stem reflexes, Evaluative conditioning, Emotional contagion, Visual imagery, Episodic memory,* and *Musical expectancy.* Further additions to the potential emotion-induction mechanisms include *Cognitive appraisal* and the possible contribution of lyrics (Juslin et al., 2010).

Brain stem reflexes comprise processes where the brain stem is alerted by certain acoustic aspects of music (e.g., loudness or speed).

Evaluative conditioning is related to the repeated pairing of an emotional stimulus with a piece of music, whereby an emotion is induced through learned associations.

Emotional contagion refers to a process where the listener internally mimics the perceived emotion expressed by a piece of music, possibly utilizing empathy-related pathways (see e.g., Scherer & Zentner, 2001).

Visual imagery refers to a mechanism where an emotion is induced through music-inspired imagery that is conjured up by the listener.

Episodic memory is related to specific, emotional memories that are evoked by music.

Musical expectancy is a mechanism where an emotion is induced when the listener's expectations about the continuation of the music are either confirmed, violated, or suspended. This mechanism was originally proposed by Meyer (1956).

Cognitive appraisal refers to a mechanism that is central to emotion theories in general (see e.g., Scherer, 2000; 2005) but perhaps rarely involved in music-induced emotions, namely the appraisal of the potential implications music may have for the listener's goals, desires, or well-being (Juslin et al., 2010).

The mechanisms *Emotional contagion* and *Episodic memory* are of particular relevance for the present work. Trait empathy may interact with the mechanism *Emotional contagion,* as empathy – especially emotional empathy – has previously been linked with emotional contagion in general (e.g., Doherty, 1997). Thus, it could be speculated that participants scoring high in trait empathy may be more susceptible to emotion induction via the *Emotional contagion* mechanism.

As the mechanism *Episodic memory* is related to specific, emotional memories, it could be speculated that familiar music evokes these types of emotional responses more often that unfamiliar music. As the emotional memories associated with a particular piece of music may be entirely unconnected to the emotion expressed by the piece, this mechanism has certain implications for studies aiming to investigate music-induced emotions. In this work, the contribution of the *Episodic memory* mechanism has been taken into consideration by utilizing mainly unfamiliar music excerpts (with the exception of Study V), thus aiming to control the contribution of extra-musical factors.

4.1.2 Aesthetic responses to music

Liking or disliking a piece of music is perhaps our most common affective response to music (see e.g., Brattico & Jacobsen, 2009). Although music preferences are highly subjective (see e.g., Rentfrow & McDonald, 2010), some general principals apply to most listeners. For instance, empirical listening experiments – building on a theory proposed by Berlyne (1970) – have shown that familiarity and liking mainly have a positive relationship (although overexposure to music may lead to decrease in liking; see e.g., Hunter & Schellenberg, 2011), and that the relationship between musical complexity and liking can be described as an inverted U (see e.g., North & Hargreaves, 1995). In other words, too simple and too complex music is disliked, while moderately or "optimally" complex music is liked.

Listening to a highly liked piece of music can have similar pleasurable, rewarding effects as food and sex (e.g., Blood & Zatorre, 2001; Salimpoor et al., 2009). Some researchers even suggest that aesthetic emotions such as "being moved" or "aesthetic awe" are perhaps the most profound emotional experiences evoked by music (Konečni, 2008; Scherer, 2004). According to the "neo-hedonic theory", music can evoke aesthetic pleasure in the listener through multiple mechanisms (see Huron, 2009). One line of research has focused on the study of aesthetic "chills" or "shivers down the spine" that are sometimes induced by music, and associated with highly pleasurable experiences (e.g., Sloboda, 1991; Blood & Zatorre, 2001). Chills and tears are also often present in strong experiences with music, together with intense and predominantly positive emotions (Gabrielsson, 2001). Chills can often be associated with particular features or passages in the music (see Sloboda, 1991), suggesting that these types of reactions may be induced by the *Musical expectancy* –mechanism (Sloboda, 1991; Juslin & Västfjäll, 2008).

4.2 Musical features

The investigation of musical features has played a central role in the study of how emotions are conveyed via music. With regard to perceived and felt emotion, the study of musical features has mainly focused on how music expresses or communicates emotions. The emotional "expression" of music is conveyed through the composed structure and performance features that involve the modification of the notated structure, including variations in tempo, articulation, and loudness (Gabrielsson & Lindström, 2001). A host of empirical studies have established distinct structural and performance features that are related to the expression of different basic emotions (for reviews, see Gabrielsson & Lindström, 2001; Juslin, 2001). For example, music expresses sadness through minor mode, low tempo, low pitch, narrow melodic range, soft timbre, and legato articulation, while happiness is expressed through major mode, fast tempo, high pitch, wide melodic range, consonant harmonies, and staccato articulation (e.g., Gabrielsson, 2009). The role of musical features in music-induced emotions have received much less attention – with the exception of chills, which have been associated with certain passages in the music (such as new or unexpected harmonies; see e.g., Sloboda, 1991; Grewe et al., 2007). However, it could be speculated that the same features that contribute to the expression of emotion also contribute to the induction of emotion, although – depending on the emotion induction mechanism – their relationship may not be as straightforward.

Although both structural and performance features contribute significantly to the emotional expression of music, computer-generated, synthetic music excerpts (e.g., MIDI) are regularly used in music and emotion research (e.g., Khalfa, Peretz, Blondin, & Manon, 2002; Vieillard et al., 2008). This raises certain concerns regarding ecological validity, as the expression of emotion is solely based on the composed structure (Gabrielsson & Linström, 2001). Juslin (2000) has shown that different performances of the same piece can effectively convey different emotions, highlighting the importance of performance features. Although synthetic stimuli may be useful in studies aiming to model performance features (Juslin, Friberg, & Bresin, 2002) or to manipulate different structural features (Lindström, 2006), studies aiming to investigate perceived or induced emotions should pay attention to the selection of appropriate musical material.

4.3 Listener attributes

Different people prefer different kinds of music, and also react differently to a given piece of music (for reviews, see Retfrow & McDonald, 2010; Abeles & Chung, 1996). Although it has been suggested that listener attributes such as personality, mood, musical expertise, and an individual's memories and learned associations may contribute significantly to music-induced emotions (see e.g., Scherer & Zentner, 2001; Abeles & Chung, 1996), few attempts have been made to investigate this empirically (Juslin, 2009). However, some links have been established between certain personality traits and certain types of affective responses to music.

A few studies have investigated the role of the *Big Five* personality traits (for descriptions of the traits, see section 3.1) in music-induced emotions. Nusbaum and Silvia (2011) found that *Openness to experience* – a trait associated with the appreciation of beauty and aesthetic experiences (see e.g., McCrae, 2007) – was reliably connected with music-induced chills, as those scoring high in the trait experienced more music-induced chills than those scoring low. Somewhat conversely, an experience sampling study of everyday music listening (Juslin et al., 2008) revealed that music-induced pleasure and enjoyment was negatively correlated with *Openness to Experience*, but positively correlated with *Neuroticism* – a trait typically associated with negative emotionality (e.g., Reisenzein & Weber, 2008). Ladinig and Schellenberg (2011) found that *Agreeableness* was positively associated with the intensity of music-induced emotions in general, suggesting that highly agreeable people may utilize their empathic tendencies when listening to music. They also discovered that *Agreeableness* and *Neuroticism* correlated with music-induced sadness (Ladinig & Schellenberg, 2011). Although most of these findings are in line with the predictions of personality theory (see section 3.1), some findings (e.g., those by Juslin et al., 2008) are somewhat counter-intuitive. The inconsistencies may result from methodological differences, and further encourage more thorough and theory-based investigation of the role of these traits in music-induced emotions.

A small amount of studies have investigated the contribution of other traits such as *Sensation seeking* (see Zuckerman, 1979) and *Absorption* (see Tellegen & Atkinson, 1974). *Sensation seeking* has been associated with experienced calmness after listening to heavy music (Nater et al., 2005), and with experienced sadness after listening to peaceful music (Rawlings & Leow, 2008). Kreutz, Ott, Teichmann, Osawa, and Vaitl (2008) discovered that *Absorption* correlated with music-induced sadness, and with the intensity of music-induced emotions in general. *Absorption* is related to a tendency empathically to identify oneself with objects of absorbed attention (Tellegen & Atkinson, 1974), which may be the factor that contributes to the intensity of music-induced emotions.

In addition, some studies have investigated individual differences in the emotional aspects of music preferences. Garrido and Schubert (2011) found that *Absorption* was positively associated with liking for sadness-inducing music together with the empathy-subscale *Fantasy*. Similarly, *Openness to experience* has also been associated with liking for sadness-inducing music (Ladinig & Schellenberg, 2011), while *Extraversion* has been associated with liking for happy music (Chamorro-Premuzic et al., 2010). *Absorption* and *Openness to Experience* have been found to be highly correlated traits, reflecting a similar tendency to appreciate aesthetic experiences and fantasize (Glisky et al., 1991). As suggested previously by the study of tragic films (De Wied et al., 1994), empathy may contribute to the enjoyment of sadness portrayed in fiction. This may also be the case for sad music, although the mechanisms behind such enjoyment are still unclear.

Finally, although mood- and trait-congruent biases in emotional processing are relatively well-known phenomena (for a review, see Rusting, 1998), musical stimuli have almost never been used to investigate them. There are, however, a few exceptions: Houston and Haddock (2007) demonstrated that participants in positive moods recalled melodies in major mode better than melodies in minor mode, while participants in negative moods displayed the opposite mood-congruent memory effect. Similarly, Punkanen, Eerola, and Erkkilä (2010) found that clinically depressed patients gave higher ratings of perceived anger and sadness (than healthy controls) to music excerpts expressing a range of emotions, thus displaying a judgment bias towards negative emotions.

4.4 Situational factors

Finally, there are the situational factors (i.e., the listening context) that contribute to music-induced emotions together with musical features and listener attributes (e.g., Scherer & Zentner, 2001; Gabrielsson, 2001). Situational factors have received even less attention than listener attributes, since their study is difficult in laboratory settings, and it has been necessary to develop novel methods for the study of everyday music listening behaviour (e.g., Sloboda et al., 2001; Juslin et al., 2008).

Garbielsson (2001) has suggested that situational factors can be divided into physical factors (such as location, acoustical conditions, and listening to recorded vs. live music) and social factors (such as listening alone or together with others, and the behaviour of the performers and the audience). In an extensive study of everyday music listening (employing the Experience Sampling Method), Juslin, Liljeström, Västfjäll, Barradas, and Silva (2008) found that musical emotion episodes were most frequent in the evening, followed by the afternoon and the morning, respectively. Musical emotion episodes were most common at home, outdoors, and at someone else's house, while the most common activities during musical emotion episodes were music listening (15%), social interaction (15%), relaxation (13%), work/study (11%), and TV/movie watching (10%). Regarding the specific types of music-induced emotions experienced in different situations, happiness-elation, pleasure-enjoyment, and anger-irritation often occurred in social settings, while emotions such as calm-contentment, nostalgia-longing, and sadness-melancholy were more common in solitary settings. These findings have implications for laboratory experiments – typically involving solitary music listening – as the setting itself may influence the types of emotions participants are likely to experience.

5 AIMS AND HYPOTHESES

The primary aim of this work is to generate new knowledge about individual differences in the different emotional phenomena related to music, and to investigate the possible contribution of the Big Five personality traits, trait empathy, and mood states to these differences. Although the potential contribution of listener features to music-induced emotions has been noted on a theoretical level (see e.g., Scherer & Zentner, 2001), few empirical studies have attempted to identify the possible traits involved. The emotional phenomena under investigation are perceived emotions (i.e., emotions that are represented by music and recognized by listeners), felt emotions (i.e., emotional responses that are induced *in* listeners by music), and preference for music expressing different emotions. As there has been no clear consensus in the field as to which emotion model(s) would be the most applicable to the study of music and emotion (see e.g., Zentner et al., 2008), the secondary aim of this work is to evaluate and compare the applicability of different emotion models in the measurement of perceived (Study I) and felt (Study III) emotions in the context of music.

Studies I and II focus on perceived emotions. Study I compares the applicability of the discrete emotion model and different formulations of the dimensional emotion model in the measurement of perceived emotions, and introduces a new stimulus set for the study of perceived emotions in music. To explore the role of individual differences in emotion perception, Study II investigates how listeners' personality traits and mood states are involved in the perception and assessment of emotions represented by music. Study II also explores whether personality and mood are related to preferences for music expressing different emotions. It is hypothesized that – as in the case of cognitive emotional processing in general (see Rusting, 1998) – mood states will bias the judgment of emotions represented by music in affect-congruent directions. In addition, it is hypothesized that personality traits will contribute to the preference ratings for music expressing different emotions in a manner similar to previously reported trait-congruent biases in self-referential emotional processing (see Rusting, 1998).

Studies III, IV and V investigate emotions induced by music (i.e., felt emotions). Study III aims to evaluate and compare the applicability of domain-specific and general emotion models – namely the Geneva Emotional Music Scale (Zentner et al., 2008), the discrete emotion model, and the 3-dimensional model (Schimmack & Grob, 2000) – in the measurement of emotions induced by music. A related aim of this study is to investigate how the Big Five personality traits, empathy, and mood states are related to emotional responses induced by music, and whether some emotion models reflect individual differences in felt emotions more strongly than others. It is expected that personality traits and mood states will contribute to felt emotions in trait- and mood-congruent manners.

Using the data collected in Study III, Study IV addresses the paradoxical enjoyment of sad music by investigating what kinds of subjective emotional experiences are induced by sad music, and whether the enjoyment of sad music is associated with particular personality traits or trait empathy. It is hypothesized that trait empathy and *Openness to Experience* will contribute to the enjoyment of sad music, as they have previously been associated with the enjoyment of cinematic tragedy (De Wied et al., 1994) and the appreciation of arts and beauty (e.g., McCrae, 2007), respectively. To extend and complement the findings of study IV, Study V investigates whether sad music can induce genuine sadness in listeners by comparing the memory and judgment effects induced by unfamiliar sad music, self-selected sad music, neutral music, and sad autobiographical recall. The role of trait empathy in music-induced sadness is of particular interest, and it is hypothesized that trait empathy will contribute to the susceptibility to music-induced sadness – particularly in the case of unfamiliar sad music. This study also explores the possible mechanisms through which unfamiliar sad music and self-selected sad music might induce sadness in listeners.

6 METHODS

The methods and materials used in the five studies are reported in detail in the original research articles I-V. The data used in this work were collected by conducting listening experiments where participants listened to music and completed different tasks. In addition, information about the participants' personality, mood, and background variables was collected using standardized psychometric measures. Statistical methods were mainly used in the data analyses. All the participants taking part in the listening experiments were Finnish university students from different faculties, with the number of participants in the different studies varying from 67 to 148. Unfamiliar excerpts of film music (pretested in pilot experiments) were used as stimuli in most of the experiments, as film music as a style should be a familiar to most participants. The aim was to use musical material that would be ecologically valid, yet relatively free from episodic memories. The different experimental tasks and the psychometric measures utilized in the experiments are described in the following sections of this chapter.

6.1 Listening experiments

All the listening experiments, independent from design, were conducted individually for each participant using a computer interface. Special computer programs that played the music excerpts and collected the data were built using *Pure Data* (Puckette, 1996) and *MAX/MSP* (version 5.1) graphical programming environments. In the studies where multiple excerpts were used, the computer programs presented the music excerpts in a different random order to each participant, and enabled the participants to move from one excerpt to the next at their own pace. Participants listened to the excerpts through studio quality headphones, and were able to adjust the sound volume according to their own preferences.

6.1.1 Self-reports of perceived emotions

Self-reports of emotions perceived in music were collected in Study I. Study II used a subsample of the data collected in Study I. The 116 participants in Study I were instructed to rate the emotions that 110 short film music excerpts expressed in their opinion. To describe the emotions expressed by the excerpts, a part of the participants used five discrete emotion scales (anger, fear, happiness, sadness, and tenderness) ranging from 1 (e.g., not at all angry) to 9 (e.g., very angry), while the other part used three bipolar scales representing the three-dimensional model of affect (Schimmack & Grob, 2000). These bipolar scales were labelled valence, energy, and tension, ranging from 1 (e.g., unpleasant, negative, bad) to 9 (e.g., pleasant, positive, good). The reason for using the three-dimensional model to collect ratings was that the three dimensions could be reduced to different two-dimensional formulations (see section 2.2) in the analyses. The participants also had to rate how much they liked each excerpt, and how beautiful they found the excerpts. These ratings were also made on bipolar scales ranging from 1 (e.g., I do not like at all) to 9 (e.g., I like very much).

Of the 110 film music excerpts used in Study I, 50 were highly and moderately typical examples of five discrete emotions (anger, fear, happiness, sadness, and tenderness), while 60 excerpts were representative of different points along the three dimensions (valence, energy, and tension). All excerpts were 15 seconds in duration. The subsample of data used in Study II included the discrete emotion ratings of 67 participants for the 50 discrete emotion examples.

6.1.2 Self-reports of felt emotions

Studies III and IV were based on the same set of data, collected in a listening experiment aiming to investigate felt emotions induced by music. One hundred forty-eight participants listened to 16 film music excerpts, and rated the emotions that the music excerpts evoked in them. The difference between perceived and felt emotions was explained to the participants, and they were instructed to focus on their own responses, not on the music. The participants were able to indicate whether the music evoked an emotional response or not by rating the intensity of their response. The participants were divided into 4 groups: Group 1 only evaluated the intensity of their emotional responses (i.e., strength of experienced emotion) and how much they liked each excerpt, while the other groups could also describe their potential emotional responses using different sets of scales. Group 2 used five discrete emotion scales (sadness, happiness, tenderness, fear, and anger), Group 3 used six unipolar scales derived from the 3-dimensional model of affect (positive and negative valence, high and low energy, and high and low tension; Schimmack & Grob, 2000), and Group 4 used the nine scales of the music-specific GEMS-9 emotion model (wonder, transcendence, power, tenderness, nostalgia, peacefulness, joyful activation, sadness, and tension; Zentner et al., 2008). All ratings were done on scales from 1 (e.g., not at all sad) to 7 (e.g., very sad).

The stimuli were 16 film music excerpts, ranging from 45 to 77 seconds in length. Using the valence and arousal ratings obtained for the set of stimuli in Study I, the excerpts were selected evenly from the 4 quadrants of the two-dimensional valence-arousal space: 4 excerpts from each quadrant. This resulted in 4 scary, 4 happy, 4 sad, and 4 tender excerpts. Since the original excerpts were too short (15 s) for emotion induction, longer excerpts (approx. 60 s) of the same pieces were taken, ensuring that the emotional characteristics of the original excerpts did not change during the longer versions. The emotions expressed by the excerpts were further verified in a pilot experiment (reported in studies III and IV).

6.1.3 Indirect measures of felt emotions

Study V was based on the premise that felt emotions induced by music can also be measured using methods other than self reports – namely indirect measures of experienced emotions. The rationale behind these indirect measures is that affective states like emotions and moods are accompanied by changes in information processing and behaviour (see e.g., Bower, 1981; Russell, 2003), and that music-induced emotional states can last longer than the duration of the music piece(s) listened to (see e.g., Västfjäll, 2002). One hundred twenty participants were randomly assigned to four conditions: Participants in condition 1 listened to an excerpt of unfamiliar, instrumental sad music; participants in condition 2 listened to neutral music; participants in condition 3 listened to self-selected sadness-inducing music; and participants in condition 4 recalled an autobiographical event that had made them very sad and wrote about it. The purpose of the autobiographical recall condition was to provide a valid point of comparison for music-induced sadness, as autobiographical recall has been shown to be one of the most effective ways to induce emotional states (e.g., Jallais & Gilet, 2010). The duration of all emotion-induction conditions was approximately 8 minutes.

The emotional states induced by the four different conditions were assessed using two indirect measures: a word recall task, and a picture judgment task. In the word recall task, the participants had two minutes to write down as many adjectives as they remembered from the 20-item *Positive and Negative Affect Schedule* (PANAS) they completed in the beginning of the experiment (for a similar task, see e.g., Hartig, Nyberg, Nilsson, & Gärling, 1999). The participants were not instructed to memorize the PANAS adjectives. In the picture judgment task, the participants rated the emotions expressed by 25 composite pictures depicting prototypical and ambiguous facial expressions (created by Vanger, Hoenlinger, & Haken, 1998) using five rating scales (anger, fear, happiness, sadness, and neutral) ranging from 1 (e.g., “not at all angry”) to 7 (e.g., “very angry”). In the end of the experiment, participants in conditions 1, 2, and 3 answered a few questions about the music listening task. They had to rate (on a scale from 1 to 7) how pleasant they found the music listening task, and how much they liked the music piece(s) they listened to. They were also asked to describe what kinds of thoughts went through their minds during the music listening (see next section). Similarly, participants in condition 4 were asked to rate how pleasant they found the autobiographical memory task.

6.1.4 Free descriptions

After completing the indirect measures, the participants of Study V (conditions 1, 2, and 3) were asked to write down what kinds of thoughts or impressions went through their minds during the music listening. The free descriptions were coded using classical content analysis, with the aim to construct classifying themes that would account for the broad, common constituents of the participants' thoughts and impressions. The emotion-induction mechanisms proposed by Juslin and Västfjäll (2008) were used as a framework for the coded themes. Each free response was coded according to the predominant theme. The data were first coded by one of the experimenters, and then verified by the other experimenter using the same criteria.

6.2 Psychometric measures

All the participants taking part in the listening experiments also completed a variety of questionnaire measures. In addition to background information about age, gender, and musical expertise, information about the participants' personality traits, trait empathy, and current mood was collected using Finnish translations of standardized psychometric measures. The different psychometric measures that were used in the present work are described in the following sections.

6.2.1 The Big Five Inventory

The Big Five Inventory (BFI; John & Srivastava, 1999) was used to assess the participants' personality traits in studies II-V. A five-factor trait structure was chosen over other personality theories and trait structures, since the five-factor structure has emerged as the dominant trait theory during the last decades (see e.g., John & Srivastava, 1999). Furthermore, specific, emotion-related predictions and hypotheses can be made regarding four of the five personality factors (e.g., Reisenzein & Weber, 2009), thus making the five-factor model relevant and appropriate for the questions addressed in the present work. The BFI was chosen over other five-factor personality measures because (a) the BFI assesses those prototypical components of the *Big Five* that are common across different formulations of the five-factor model (see John & Srivastava, 1999), (b) the BFI is relatively short and thus less time-consuming, and (c) the BFI is available for free. The BFI has 44 items that measure the five personality traits of *Extraversion, Agreeableness, Conscientiousness, Neuroticism,* and *Openness to experience* (see section 3.1 for descriptions of the traits). The items were rated on a 5-point Likert scale ranging from 1 (disagree strongly) to 5 (agree strongly).

6.2.2 The Interpersonal Reactivity Index

The Interpersonal Reactivity Index (IRI; Davis, 1980) has 28 items that tap two separate aspects of global empathy: The cognitive, perspective-taking capabilities, as well as the emotional reactivity of an individual. The reason for investigating the potential contribution of trait empathy was that previous, theoretical papers discussing the mechanisms behind music-induced emotions have mentioned empathy and emotional contagion as potential contributors (e.g., Scherer & Zentner, 2001; Juslin & Västfjäll, 2008). The IRI was chosen over other empathy measures because it treats empathy as a multidimensional variable, and thus allows a more detailed investigation of the separate components. The IRI has four subscales: *Fantasy, Perspective-taking, Empathic concern, and Personal distress* (see section 3.3 for definitions of the subscales). The items were rated on a 5-point Likert scale ranging from 1 (does not describe me well) to 5 (describes me very well). The IRI was used to assess the participants' trait empathy in studies III-V.

6.2.3 Mood measures

Three different mood measures were used in the three studies (studies II, III, and V) involving mood-related analyses. In Study II, the participants' current mood prior to the experiment was measured using the *Profile of Mood States-Adolescents* questionnaire (POMS-A; Terry et al., 1999; see Terry et al., 2003 for validation for adult populations), which has 24 items that measure 6 factors of mood (*Vigour, Confusion, Anger, Fatigue, Depression*, and *Tension*). In order to collect mood data that would be more balanced in terms of both positive and negative affect (and in order to make the mood data more compatible with the collected emotion ratings), the UWIST Mood Adjective Checklist (UMACL; Matthews, Jones, & Chamberlain, 1990) was used to measure the participants' mood states in Study III. The UMACL has 24 items that measure three broad dimensions of mood: *Hedonic tone, Energetic arousal,* and *Tense arousal*. In Study V, the participants' mood states were measured using the *Positive and Negative Affect Schedule* (PANAS; Watson, Clark & Tellegen, 1988). The PANAS has 10 adjectives measuring positive affect, and 10 measuring negative affect. The reason for using the PANAS in Study V was that it could also be used for the word recall task (see section 3.1.3), as it has an equal number of both positive and negative mood adjectives. All mood ratings were made on 5-point scales ranging from 1 (not at all) to 5 (very much).

7 RESULTS

The results (including tables and figures) of the five studies are reported in detail in the original research articles I-V.

7.1 Individual differences

7.1.1 Perception of emotions represented by music

Study II utilized correlation and regression analyses to explore the contribution of personality traits and mood states to the ratings of emotions represented by music. Correlation analysis revealed that participants in negative moods gave higher sadness ratings and lower happiness ratings to music excerpts (on average), while participants in positive moods displayed the opposite pattern – giving support to the affect-congruency hypothesis. Similarly, the personality trait *Extraversion* correlated negatively with the participants' mean sadness ratings, while *Neuroticism* and sadness ratings had a positive correlation. Thus, both personality and current mood were associated with trait- and mood-congruent biases in the participants' emotion ratings. However, partial correlations suggested that mood played a more significant role in the rating biases than personality. Although personality traits such as *Extraversion* and *Neuroticism* predispose to positive and negative mood states (respectively), moderated multiple regression analyses revealed that the personality trait *Extraversion* also moderated the effect of current mood on emotion ratings. The moderated regression models accounted for 12-21% of the inter-subject variance in the participants' happiness and sadness ratings.

7.1.2 Liking for music expressing different emotions

Studies II and IV investigated whether liking for music expressing certain emotions was associated with certain personality variables. In Study II, correlation analysis revealed that the Big Five personality traits were strongly connected with preference ratings for music excerpts expressing different emotions. *Agreeableness* was associated with liking for happy and tender music, and with disliking for angry and fearful music. *Extraversion* correlated with liking ratings for happy excerpts, while *Openness to experience* correlated with liking ratings for sad and scary excerpts. *Openness to experience* and empathy were associated with liking for sad music also in Study IV, further suggesting that aesthetic appreciation and empathetic engagement may play a role in the enjoyment of sad music. Overall, the correlations between personality traits and liking ratings reflected the trait-congruent patterns obtained in studies investigating self-referential emotional processing, giving support to the trait-congruency hypothesis.

7.1.3 Self-reports of emotions induced by music

Studies III and IV set out to explore whether certain personality traits or moods are related to certain types of felt emotions, and whether the intensity of emotional responses induced by different types of music is also associated with these variables. Study III revealed that certain personality traits and mood states correlated with the reported intensity of emotional responses evoked by excerpts expressing different emotions. *Agreeableness* was connected with the intensity of emotional responses evoked by tender excerpts. Similarly, *Openness to experience* and the empathy-subscale *Fantasy* correlated with the intensity of emotional responses evoked by tender and sad excerpts. Study IV demonstrated that participants scoring high in the traits *Openness to experience* and empathy also reported experiencing more positive valence in response to sad excerpts. Although Study III did not reveal trait-congruent patterns in the different types of felt emotions reported, the intensities of emotional responses (evoked by excerpts expressing different emotions) were in line with the trait-congruency prediction.

Study III further revealed that positive and active moods were related to higher overall intensity of experienced emotions. Positive mood also correlated with the intensity of emotional responses evoked by scary excerpts, while active mood correlated with the intensity evoked by sad excerpts. Conversely, tense mood was negatively correlated with the intensity of emotional responses evoked by happy and tender excerpts. In other words, music expressing positive emotions evoked milder emotional responses when the emotions expressed were incongruent with the listener’s current mood state, while the opposite was true for music expressing negative emotions.

7.1.4 Responsiveness to sadness-inducing music

Study V investigated whether self-selected and unfamiliar sad music could induce sadness-related changes in emotion-related memory and perception. Two indirect measures of experienced affect – a word recall task and a picture judgment task – demonstrated that self-selected sadness-inducing music and sad autobiographical recall could indeed induce memory and judgment effects that were significantly different from the neutral condition. Participants in both groups remembered more positive words in relation to negative words (i.e., affect-incongruent memory bias), and perceived more sadness and less happiness in facial pictures (i.e., affect-congruent judgment bias) than the participants in the neutral control group. However, experimenter-selected, unfamiliar sad music was able to successfully induce a sad emotional state only in participants scoring high in trait empathy, as highly empathic participants displayed a judgment bias that was significantly different from the neutral group, while participants scoring low in empathy did not display a judgment bias. This finding supports the hypothesis regarding the contribution of trait empathy to the susceptibility to music-induced sadness. Forty-seven percent of the participants listening to self-selected sadness-inducing music reported thinking about sad personal events while listening to music, suggesting that autobiographical memories may contribute significantly to sadness induced by familiar music. The vast majority of the participants listening to unfamiliar sad music did not report thinking about personal memories during the music listening, suggesting that real sadness can be experienced through emotional contagion.

7.2 Emotion model comparisons

7.2.1 Perceived emotions

The discrete and dimensional ratings of perceived emotions collected in Study I were compared using a variety of analysis methods. There were no substantial differences in the overall consistencies of ratings (Cronbach alpha) between the dimensional and discrete models of emotion. The only notable difference was that the discrete model was somewhat weaker in characterizing emotionally ambiguous examples. Linear mapping techniques (canonical correlation and regression analysis) between the discrete and dimensional models revealed a high correspondence along two central dimensions that can be labeled as valence and arousal. Regression analyses suggested that dimensional ratings can be predicted from discrete emotion ratings with higher accuracy (mean R^2 = .93) than the other way around (mean R^2 = .70-76, depending on the type of dimensional model used). The comparisons between the three-dimensional and two-dimensional versions of the dimensional emotion model suggested that two dimensions (valence and arousal, or tension and arousal) may be sufficient to represent perceived emotions in music, as the valence and tension dimensions were highly correlated.

7.2.2 Felt emotions

Study III set out to compare the ratings of felt emotions collected using the 3-dimensional model, discrete emotions, and the GEMS-9 model. The overall consistency of ratings obtained with the 3-dimensional model (mean Cronbach's alpha .97; mean intraclass correlation .41) was higher than the consistencies of the discrete (.96; .36) and GEMS-9 (.90; .36) models. Two scales of the GEMS-9 model – *Wonder* and *Transcendence* - were especially problematic, as their consistencies were considerably lower than those of the other GEMS scales. Cluster analyses revealed that the dimensional model also outperformed the other two models in the discrimination of music excerpts, providing the clearest and most coherent clusters of excerpts. Principal component analysis indicated that 89.9% of the variance in the mean ratings of all three models could be accounted for by two principal components that could be interpreted as valence and arousal, suggesting that there is a great deal of scale redundancy in the GEMS and discrete models. Furthermore, those participants who used discrete emotion scales to describe their emotional responses reported significantly lower intensities of experienced emotions than the other participants, suggesting that at least some participants may have found some of the discrete emotion scales inapplicable to their experienced emotions.

8 DISCUSSION AND CONCLUSIONS

8.1 The role of individual differences

The findings of this work suggest that factors such as personality, mood, and empathy contribute notably to individual differences in music-related emotional phenomena. The emotional phenomena under investigation were perceived emotions (i.e., the perception of emotions expressed by music), liking/disliking for music expressing different emotions, and felt emotions (i.e., emotional responses induced by music). This section will briefly summarize the main findings regarding each emotional phenomenon, and discuss them in the light of current theories on personality and emotional processing.

In the present work, temporary mood states were reliably associated with mood-congruent biases in the ratings of perceived emotions. Although this finding is in line with previous studies that have associated mood states with mood-congruent rating biases in general (e.g., Bouhuys et al., 1995; Isen & Shalker, 1982), the present work is – to the best knowledge of the author – the first study that has discovered mood-congruent judgment biases in the context of music and emotions. These findings may explain why a given piece of music may sound sad to us on one day, and neutral on the next. Furthermore, the present work also demonstrated that – in addition to predisposing to positive mood states – the personality trait *Extraversion* also moderated the effect certain mood states had on the ratings of perceived emotions. Similar findings have also been obtained previously in other domains, but only after mood had been manipulated (e.g., Rusting, 1999). These findings suggest that the judgment of emotions expressed by music is similarly influenced by mood and personality as the judgment of other stimuli such as picture slides (e.g., Isen & Shalker, 1982). However, the liking ratings for the same music excerpts revealed a somewhat different kind of pattern.

Previous studies on music preferences have mainly investigated the links between personality traits and genre preferences (e.g., Rentfrow & Gosling, 2003), but the emotional aspects of music preferences have received less attention (for a review, see Rentfrow & McDonald, 2010). However, the results of the present work suggest that music preferences appear to be highly dependent on the emotional tone of the music. Liking ratings for music excerpts expressing different emotions correlated consistently with personality traits, while the contribution of current mood was minor. Furthermore, these correlations reflected trait-congruent patterns, which is in line with the notion that people preferentially process stimuli that are emotionally congruent with their personality traits (e.g., Rusting, 1998).

The simultaneous investigation of emotion perception and liking enabled the comparison of the relative contributions of personality and mood in these two phenomena. Mood states contributed more to the ratings of emotions expressed by music (although some of the mood-congruency effects were moderated by *Extraversion*), while personality traits contributed more to liking ratings. These connections resemble those proposed by Rusting (1998) with regard to cognitive and self-referent emotional processing (see Figure 1). It could be argued that the perception and judgment of emotions expressed by music could be described as a form of cognitive emotional processing, while liking or disliking for emotional stimuli such as music may be related to self-referent emotional processing, as self-referent emotional judgments are also associated with trait-congruent (rather than mood-congruent) biases.

The third music-related emotional phenomenon investigated in this work was music-induced emotion, measured using self-reports and indirect measures of felt emotion. Although the self-reports revealed no significant correlations between personality traits (or mood states) and specific felt emotions – partly because of the small group sizes in Study III – the correlations regarding the overall intensity of felt emotion induced by different types of excerpts revealed interesting connections. These correlations resembled those obtained with liking/disliking ratings, with the distinction that – in addition to trait-congruent correlations – the intensity of felt emotion was also associated with current mood.

Agreeableness was associated with the reported intensity of emotional responses evoked by tender excerpts, while *Openness to experience* correlated with the intensity of emotional responses evoked by tender and sad excerpts. Study IV demonstrated that participants scoring high in *Openness to experience* also reported experiencing more pleasant feelings in response to sad excerpts. Previous studies investigating individual differences in emotional processing have mainly focused on the traits *Extraversion* and *Neuroticism*, as they are strongly associated with positive and negative emotional dispositions, respectively. However, the results of the present work suggest that *Agreeableness* and *Openness to Experience* should not be neglected in future studies, as their contributions appeared to be even more significant than those of *Extraversion* or *Neuroticism*. Although the notion of trait congruence is not very well-formed in the case of *Agreeableness* and *Openness to Experience*, the findings of the present work seem to support the definition of *Agreeableness* as a pro-social trait (reflecting tender-mindedness and kindness), as well as the links between *Openness to Ex-*

perience, openness to feelings, and the appreciation of beauty and aesthetic experiences.

Positive and active moods were associated with a higher overall intensity of reported felt emotion. The connection between active mood and reported intensity might be at least partly explained by the higher arousal level of active mood states, as induced physiological arousal has previously been connected with higher intensity of emotional responses evoked by music (Dibben, 2004). However, the most intriguing finding was that music expressing *positive* emotions evoked milder emotional responses when it was incongruent with the listener's current mood state (a finding consistent with the mood-congruency literature), whereas music expressing *negative* emotions functioned in an opposite manner (i.e., positive mood correlated with the intensity of emotional responses evoked by scary excerpts, while active mood correlated with the intensity evoked by sad excerpts). One explanation for these affect-incongruent correlations may be that the participants in negative and tired moods tried to repair their mood (see, e.g., Isen, 1985) and did not let themselves be absorbed in music expressing negative emotions, while the participants in positive and active moods were more open towards different types of music. Another possible explanation is that participants in negative moods experienced less intense emotional responses in general. Although the overall intensity of induced emotions was not correlated with tension, it was positively correlated with hedonic tone (i.e., valence). However, this issue requires further investigation with more varied musical material.

The indirect measures of felt emotion revealed that listening to sad music could induce sadness-related changes in memory and judgment. There were no notable individual differences in the responsiveness to self-selected sad music, but trait empathy played a significant role in the responsiveness to unfamiliar sad music. This suggests that unfamiliar and familiar music may induce emotional responses through slightly different mechanisms. Almost half of the participants listening to self-selected music reported thinking about autobiographical memories during the music listening, suggesting that the mechanism *episodic memory* may be heavily involved in emotional responses evoked by familiar music. In comparison, the mechanism that was most often mentioned by the participants listening to unfamiliar sad music was *visual imagery* (23%). As highly empathic participants were more susceptible to music-induced sadness than non-empathic participants, it could be speculated that the mechanism *emotional contagion* may have contributed to music-induced sadness in the case of unfamiliar music.

An interesting link may be formed between the findings of studies IV and V: In study IV, trait empathy was identified as one of the traits that contribute to the enjoyment of sad music, while in Study V this same trait was associated with the susceptibility to music-induced sadness. This suggests that the experience of intense music-induced sadness is associated with the enjoyment of sad music, which opens intriguing new directions for future work. For example, Huron (2011) has suggested that the consoling hormone prolactin may be involved in the enjoyment of sad music, as higher prolactin levels have previously been associated with induced sadness (e.g., Turner et al., 2002). Although this proposition still lacks empirical evidence, the findings of the present work at least suggest that sad music can induce genuine sadness that is nevertheless enjoyed, as the same trait was implicated in both the enjoyment of sad music and the susceptibility to music-induced sadness.

8.2 Music-specific or general emotion models?

One of the aims of this work was also to systematically compare the applicability of different emotion models in the measurement of perceived and felt emotion. In the case of perceived emotions, the discrete and dimensional models were difficult to rank. The discrete emotion ratings predicted dimensional ratings with greater accuracy than vice versa, although the dimensional ratings characterized ambiguous excerpts better than the discrete emotion ratings. However, in the case of felt emotions, the dimensional model outperformed the discrete model and the GEMS on several measures. It could be speculated that a wider range of discrete or "basic" emotions are more commonly expressed rather than induced by music, as the findings of Study III suggested that at least some participants may have found some of the discrete emotion scales inapplicable to their felt emotions. This conclusion is also supported by the findings of Juslin and Laukka (2004), who asked participants to rate which emotions music commonly expressed and induced in their opinion. A wider range of basic emotions was represented in the list of emotions most commonly expressed by music, while the list of emotions commonly induced by music only included some basic emotions in addition to more nuanced emotions such as "being moved" and "nostalgia".

However, why did the three-dimensional model appear to outperform the music-specific GEMS in the measurement of music-induced emotions? It could have been expected that the GEMS would have been superior in this task, as it has been specifically constructed to represent emotions induced by music. There are at least three possible explanations: First, it may be that some of the responses measured by the GEMS – such as *transcendence* or *wonder* - are rare and only evoked by very specific types of music. Second, it may also be that these types of responses are highly subjective, and thus the *transcendence* and *wonder* scales performed poorly on measures such as inter-rated agreement. And third, as different people may choose to associate a given music-induced emotion with different verbal labels (see e.g., Gabrielsson, 2002) – and as the choice of verbal labels is restricted by the rating scales provided by researchers – broad dimensional labels such as "positive" and "pleasant" may be more flexible and accommodating than the very specific GEMS labels (e.g., "filled with wonder" or "fascinated"). Nevertheless, 90% of the variance in all three emotion models – the discrete, three-dimensional, and GEMS – was accounted for by two principal components that could be interpreted as valence and arousal.

This suggests that a range of music-induced emotions can quite adequately be described using only two dimensions. However, it has to be noted that the musical stimuli used in Study III represented the valence-arousal space in a balanced way, and thus the musical material may have favoured the dimensional model. In any case, further research with varied musical stimuli from different genres is required, and it may even be discovered that the applicability of different emotion models varies depending on the musical genre under investigation.

In the case of both perceived and felt emotion, the dimensional structure of affect appeared to be two-dimensional rather than three-dimensional. This was mainly due to the fact that the valence and tension dimensions appeared to be highly (negatively) correlated. However, as noted earlier, it has to be taken into consideration that the results obtained in this work only reflect the musical material used as stimuli, and thus it could be possible to find musical material where these two dimensions were not correlated. However, it appears that – at least in the case of most music – valence and tension are not entirely independent dimensions.

8.3 Limitations

As the focus of the present work has been on individual differences and emotion model comparisons, it has to be acknowledged that other important aspects related to music and emotions – such as musical and situational factors – have mostly been left unexplored. As it has been postulated that music-induced emotions emerge from the interplay of the music, the situation, and the listener (e.g., Scherer & Zentner, 2001), a comprehensive picture of the phenomenon cannot be achieved without taking all three factors into consideration. However, this formidable undertaking requires preliminary knowledge of the separate contributions of the different factors before any feasible experimental set-ups combining the three factors can be attempted.

As already noted earlier in this chapter, it has to be taken into consideration that the results obtained in this work partly reflect the musical material used as stimuli. This is probably the case with the emotion model comparisons in particular. The musical material was mostly film music, but also music selected by the participants themselves. This arguably limits the generalizability of the results, as different musical material would probably have provided different results. However, care was taken to select excerpts that would be unfamiliar (yet stylistically familiar) to most participants, and the excerpts were very varied in terms of emotional clarity and the type of emotion conveyed. The generalizability of findings is also limited by the sample of people used as participants. All the participants of the studies included in this work were Finnish university students from different faculties, and thus the findings cannot be generalized over different cultures, age groups, or socio-economic classes – albeit the university students in Finland represent quite a heterogeneous group in terms of age and socio-economic background.

Another issue that limits the findings concerns the measurement of perceived and felt emotion. As the participants were provided with rating scales that they had to use to describe their perceived and felt emotions, this restricted the kinds of responses they could give. Although multiple sets of rating scales were used in most of the studies, the results nevertheless reflect the choices made in the selection of rating scales. The only way to avoid this limitation would be to collect free responses from participants, but this would not have been a viable option considering that a related aim of this work was to compare different sets of rating scales. It also has to be noted that the rating scales used in this work (e.g., the GEMS) – as well as the psychometric measures – were translated from English to Finnish by the author. To verify that no important nuances were lost in translation, validation and back-translation operations need to be carried out. However, this line of work has only just begun.

Some researchers have also argued that self-report measures of felt emotion rely too much on the accuracy of introspection (see e.g., Kivy, 1989; Västfjäll, 2010), and they are also vulnerable to demand characteristics (e.g., Orne, 1962). In other words, if the participants are asked to report their felt emotions, they might either confuse their own responses with the emotions expressed by the music, or they might report experiencing an emotion (even if they did not) just to please the researcher. This is also a possibility in the present work, although such potential sources of error were minimized by providing clear instructions to participants (see e.g., Study IV). Furthermore, it cannot be reliably confirmed whether the judgment biases in the reported felt and perceived emotions actually reflected biases in actual emotion experience and perception, or whether these biases only existed on the level of self-report. However, the indirect measures of experienced emotions utilized in the present work indicate that some personality-related effects also exist on the level of actual emotion experience. Moreover, the results of the indirect measures were in line with the results obtained with self-report scales, suggesting that self-reports may indeed reflect actual emotion experience.

The indirect measures of experienced emotions are relatively free from problems such as demand characteristics and the need for accurate introspection. However, the problem with indirect measures is that – rather than asking the participants to describe their subjective feeling – one has to rely on the interpretation of indirect effects such as memory or judgment biases, which are not always clear-cut. In the case of Study V, the only way of confirming that the memory and judgment biases were indeed caused by music listening was to verify that there were no pre-existing differences in the emotional states of the participants in the different groups. As there are limitations with both self-report and indirect measures, the combination of findings obtained with these two measures should lead to more reliable conclusions. In future, physiological indicators of emotions (e.g., skin conductance, respiration, heart rate variability, facial EMG, etc.) could also be measured to corroborate the experienced emotions (see e.g., Lundqvist et al., 2009).

8.4 Implications for future studies

The results of the present work have implications not only for the field of music and emotions, but also for emotion research in general. This work has demonstrated that musical stimuli provide a realistic and effective way of exploring the interactions of mood and personality in emotional processes, and they also allow exploring the more cognitive and self-referential aspects of emotions simultaneously. In addition to showing that the judgment of emotions expressed by music is biased by mood states (similarly to the judgment of other emotional stimuli), Study II demonstrated that personality traits may moderate the degree of mood-congruence in cognitive emotional processing even when mood is not manipulated (c.f., Rusting, 1999). As the extent of mood-congruent biases was rather significant, this is something that could and should be taken into consideration in future studies investigating perceived emotions in music. In addition, future neuroimaging studies on music and emotions should move beyond group-averaged brain activations and include individual difference measures in their analyses, as it has been shown that personality traits alter the processing of emotional stimuli in the brain (e.g., DeYoung & Gray, 2009; Canli et al., 2002). This work has provided preliminary evidence regarding the traits and states that are involved in different music-related emotional phenomena.

Study V revealed that the susceptibility to music-induced sadness is associated with trait empathy. This finding has implications for studies aiming to affect participants' emotions or moods through music listening (including so-called mood-manipulation studies). As trait empathy contributed significantly to the emotional responsiveness to unfamiliar sad music, this limits the effect sizes and generalizability of findings in studies utilizing such stimuli. Furthermore, this finding encourages further investigation into how empathy is associated with the susceptibility to different types of music-induced emotions. It may very well be that empathy will turn out to be *the* individual difference variable that affects our emotional relationships with music.

Regarding the findings of the emotion model comparisons, it is recommended that future studies investigating music-induced emotion pay careful attention to the selection of an appropriate set of rating scales. As the discrete emotion model appeared to attenuate the rated intensity of felt emotions, it is suggested that future studies would at least consider the possibility that a limited number of discrete emotion scales may notably restrict the scope of potential responses. Furthermore, the GEMS may be the most applicable in studies that investigate strong, aesthetic responses to music. Overall, the findings of the present study suggest that the dimensional model may provide the most coherent and reliable ratings in studies where varied stimuli are used.

8.5 Concluding remarks

This work demonstrated that music can induce genuine, intense emotional responses even in laboratory circumstances. Furthermore, these responses – as well as emotion perception and preference – are significantly influenced by individual difference variables. Especially empathy appears to be a crucial trait that should be investigated further, as it may contribute to the susceptibility to a variety of music-induced emotions. The effect of personality and mood overlapped in the case of music-induced emotions, and personality also moderated the effect of mood on emotion judgment. However, as emotional dispositions – and thus the susceptibility to certain moods – are an inseparable part of personality traits, it is impossible to draw clear distinctions between the separate effects of mood and personality. Nevertheless, this work has provided the first account of the relative contributions of mood and personality to different music-related emotional phenomena, and discussed these findings with regard to current theories of personality and emotional processing.

Future work on the role of individual differences in music-related emotional phenomena is encouraged, as this work did not exhaustively cover different individual difference variables, different types of music, or different listening situations. It is expected that the interactions between the three factors – the music, the listener, and the situation – are rather complex, and will provide fruitful topics of research for years to come. Furthermore, it is recommended that future studies on music and emotions will continue to critically evaluate different emotion models, methods, and stimuli, and thus advance the empirical study of music and emotions.

TIIVISTELMÄ

Yksilöllisten erojen merkitys musiikillisten emootioiden havaitsemisessa ja kokemisessa

Tämän väitöskirjan ensisijaisena tavoitteena oli tutkia miten erilaiset yksilölliset tekijät – kuten persoonallisuus, empatia ja mieliala – ovat yhteydessä musiikin ilmaisemien ja herättämien emootioiden havaitsemiseen ja kokemiseen. Lisäksi tarkasteltiin yksilöllisten tekijöiden yhteyttä erilaisia emootiota ilmaisevasta musiikista pitämiseen. Väitöskirjan toisena tavoitteena oli vertailla systemaattisesti erilaisten emootiomallien soveltuvuutta musiikin ilmaisemien ja herättämien tunteiden tutkimiseen ja kuvaamiseen. Väitöskirja pitää sisällään viisi erillistä artikkelijulkaisua, joilla on erilliset (joskin toisiinsa läheisesti liittyvät) tavoitteet. Persoonallisuus- ja emootioteorioista nousevia hypoteeseja sovellettiin musiikin kontekstiin, ja testattiin hyödyntäen kokeellisen psykologian menetelmiä.

Väitöstutkimuksen tulokset viittaavat siihen, että kuulijan persoonallisuus, mieliala ja piirretyyppinen empatia ovat vahvasti yhteydessä yksilöllisiin eroihin musiikin välittämien emootioiden havaitsemisessa ja kokemisessa. Mieliala oli yhteydessä mielialansuuntaisiin vääristymiin musiikin ilmaisemien emootioiden arvioinnissa, kun taas persoonallisuus oli yhteydessä tietynlaisia emootioita ilmaisevasta musiikista pitämiseen. Persoonallisuus oli myös yhteydessä musiikin herättämien emootioiden koettuun voimakkuuteen. Piirretyyppinen empatia oli positiivisesti yhteydessä musiikin herättämän, todellisen surun voimakkuuteen, sekä myös surullisesta musiikista pitämiseen. Tämä viittaa siihen että musiikin herättämän surun ja surullisesta musiikista pitämisen välillä saattaa olla yhteys. Eri emootiomallien vertailu paljasti että kolme- tai kaksiulotteinen, ”dimensionaalinen” emootiomalli soveltuu luotettavuutensa ja mukautuvuutensa ansiosta parhaiten musiikin välittämien emootioden tutkimiseen.

Tämän väitöstutkimuksen tulokset näyttäytyvät merkityksellisinä tulevien, musiikin välittämiä emootioita tarkastelevien tutkimusten näkökulmasta. Tulosten perusteella on suositeltavaa, että tulevissa tutkimuksissa – erityisesti musiikin ja emootioiden aivotutkimuksessa – kiinnitetään aiempaa suurempaa huomiota yksilöllisten tekijöiden vaikutukseen. Lisäksi käytettävien emootiomallien ja arviointiasteikoiden valinnassa tulisi ottaa huomioon eri mallien soveltuvuus erilaisiin tutkimuskysymyksiin, sekä valintojen mahdollinen vaikutus tuloksiin.

Avainsanat: Musiikki, emootiot, persoonallisuus, mieliala, empatia, emootiomallit

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ORIGINAL PAPERS

I

A COMPARISON OF THE DISCRETE AND DIMENSIONAL MODELS OF EMOTION IN MUSIC

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A comparison of the discrete and dimensional models of emotion in music

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Abstract

The primary aim of the present study was to systematically compare perceived emotions in music using two different theoretical frameworks: the discrete emotion model, and the dimensional model of affect. A secondary aim was to introduce a new, improved set of stimuli for the study of music-mediated emotions. A large pilot study established a set of 110 film music excerpts, half were moderately and highly representative examples of five discrete emotions (anger, fear, sadness, happiness and tenderness), and the other half moderate and high examples of the six extremes of three bipolar dimensions (valence, energy arousal and tension arousal). These excerpts were rated in a listening experiment by 116 non-musicians. All target emotions of highly representative examples in both conceptual sets were discriminated by self-ratings. Linear mapping techniques between the discrete and dimensional models revealed a high correspondence along two central dimensions that can be labelled as valence and arousal, and the three dimensions could be reduced to two without significantly reducing the goodness of fit. The major difference between the discrete and categorical models concerned the poorer resolution of the discrete model in characterizing emotionally ambiguous examples. The study offers systematically structured and rich stimulus material for exploring emotional processing.

Key words

battery, dimensional, music, discrete, emotion, three-dimensional

Music has the ability to convey powerful emotions. This ability has fascinated researchers as well as the general public throughout the ages, and although great strides forward have been made in the field of music and emotion research, much remains unclear. One issue that has been holding back advances in understanding the complex phenomena of music-mediated emotions has been the abundance of different emotion theories and concepts – discrete, dimensional, music-specific or something else altogether. Before focussing on novel, music-specific

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models (e.g., Zentner, Grandjean, & Scherer, 2008), there is a need to first critically compare the discrete and dimensional models of emotions in music because these are the two dominant models used in music and emotion research (Juslin & Sloboda, 2010; Zentner & Eerola, 2009), and they are often implied to be highly convergent although this has not actually been explicitly studied. Secondly, neurological studies (Gosselin et al., 2005; Khalfa et al., 2008b) have indicated that different processes may be involved in the discrete and dimensional assessments of emotions. Thirdly, recent hybrid models of emotion (Barrett, 2006; Christie & Friedman, 2004; Russell, 2003) depend on finding the ways in which core affects (taken to be dimensional) interact with the conscious interpretation of what people know about emotions (best described in discrete terms). And finally the understanding of musical and acoustic features that contribute to emotions would greatly benefit from knowing which model – dimensional or discrete – maps the feature space in the most ecological fashion.

Another hindrance in music and emotion research has been the choice, quality, and amount of musical examples used as stimuli. Previous studies have predominantly used well-known excerpts of Western classical music, which have been chosen arbitrarily by the researchers. Moreover, the stimuli have mostly been highly typical exemplars of the chosen emotions even if the underlying emotion model does not imply that emotions are structured around specific categories. We will address these issues in detail later.

In this article, we focus on perceived emotions (in other words, emotions that are represented by music and perceived as such by the listener). An overview of the literature implies that the border between the two alternatives – emotion recognition and emotion experience – may be somewhat blurred in reality, and it has even been suggested that the two alternatives could be seen as opposite extremes of a continuum (Gabrielsson, 2001). In addition recent empirical studies have found more similarities than differences between the two (Evans & Schubert, 2008; Kallinen & Ravaja, 2006; Vieillard et al., 2008).

To address the theoretical diversity in depth, we will first briefly summarize the prominent kinds of emotion models and their relevance for music. During the past decade, discrete models, different dimensional models, and domain-specific emotion models have all received support in studies of music and emotion (Ilie & Thompson, 2006; Krumhansl, 1997; Schubert, 1999; Zentner et al., 2008). According to the well-known discrete emotion model – the basic emotion model – all emotions can be derived from a limited number of universal and innate basic emotions such as fear, anger, disgust, sadness and happiness (Ekman, 1992, 1999). The basic emotion model builds on the assumption that an independent neural system subserves every discrete basic emotion. However, neuro-imaging and physiological studies have failed to establish reliable, consistent evidence to support this theory (for a review, see Barrett & Wager, 2006; Cacioppo, Berntson, Larsen, Poehlmann, & Ito, 2000), and the matter remains under debate. In studies investigating music and emotion, the basic emotion model has often been modified to better describe the emotions that are commonly represented by music. For example, basic emotions rarely expressed by music, such as disgust, are often changed to more suitable emotion concepts like tenderness or peacefulness (Balkwill & Thompson, 1999; Gabrielsson & Juslin, 1996; Vieillard et al., 2008). It still remains to be clarified whether models and theories designed for utilitarian emotions (Scherer, 2004) – such as the basic emotion model – can also be applied in an aesthetic context such as music. It has been argued and empirically demonstrated that a few primary basic emotions seem inadequate to describe the richness of the emotional effects of music (Zentner et al., 2008). In their study, Zentner and colleagues (2008) proposed a new model for music-induced emotions by first compiling music-related emotion terms and uncovering the underlying emotion structure with exploratory factor analysis, and then corroborating their findings by means of confirmatory factor analysis. The resulting nine-factor Geneva Emotion Music Scale (GEMS) model consists of wonder, transcendence, tenderness, nostalgia, peacefulness, power, joyful activation, tension and sadness. For music and emotions studies, this model provides much needed domain-specificity and emphasizes the positive and reflective nature of music-induced emotions. Although it was shown that the GEMS model outperformed discrete and dimensional emotion models in accounting for felt emotions in music, in our opinion, these results can be disputed as they pitted musically non-relevant formulations of the basic emotions and dimensions against GEMS and relied on a handful of familiar classical music examples. The focus of the present study is to compare the traditional models of emotion in music and also to focus on perceived emotions. This is a different emphasis to that of GEMS, although the scale has implications which will be discussed further.

In recent years, two-dimensional models of emotion have gained support among music and emotion researchers (e.g., Gomez & Danuser, 2004; Schubert, 1999; Withvliet & Vrana, 2006). Instead of an independent neural system for every basic emotion, the two-dimensional circumplex model (Posner, Russell, & Peterson, 2005; Russell, 1980) proposes that all affective states arise from two independent neurophysiological systems: one related to valence (a pleasure–displeasure continuum) and the other to arousal (activation–deactivation). In other words, all emotions can be understood as varying degrees of both valence and arousal. In contrast, Thayer (1989) suggested that the two underlying dimensions of affect were two separate arousal dimensions: energetic arousal and tense arousal. According to Thayer's multidimensional model of activation, valence could be explained as varying combinations of energetic arousal and tense arousal. A visual summary of the two-dimensional models of Russell and Thayer is given in Figure 1. In the music domain, Vieillard and colleagues explored emotional excerpts of music by means of similarity ratings, and found that the excerpts could be mapped onto a two-dimensional plane in which the salient dimensions could be best explained in terms of energy and tension (Vieillard et al., 2008). However, the two-dimensional models have been criticized for their lack of differentiation when it comes to emotions that are close neighbours in the valence-activation space, such as anger and fear (see e.g., Tellegen, Watson, & Clark, 1999). It has also been discovered, that the two-dimensional model is not able to account for all the variance in music-mediated emotions (Bigand, Vieillard, Madurell, Marozeau, & Dacquet, 2005; Collier, 2007; Ilie & Thompson, 2006).

Wilhelm Wundt suggested a distinction be made between three dimensions of emotions already as early as 1896. These three dimensions were pleasure–displeasure, arousal–calmness, and tension–relaxation. Although the two-dimensional models have a dominant position in affect literature, there is some evidence of the model's incompatibility with affect data (Schimmack & Grob, 2000; Schimmack & Reisenzein, 2002). Previous studies have shown that arousal–calmness and tension–relaxation dimensions cannot be reduced to one arousal dimension (Schimmack & Grob, 2000; Schimmack & Reisenzein, 2002). The underlying reason is that the two activation dimensions are related to different causes: unlike tense arousal, energetic arousal is affected by a circadian rhythm (Thayer, 1989; Watson, Wiese, Vaidya, & Tellegen, 1999), and the two arousal dimensions have been shown to change in opposite directions when specifically manipulated (Gold, MacLeod, Deary, & Frier, 1995). In sum, both main theoretical models – discrete and dimensional – will be investigated simultaneously to clarify their dependencies and applicability to music and emotions. The three-dimensional model, shown visually in Figure 1, will be used to collect data regarding the dimensional approach as it still allows us to examine post facto whether a lower dimensional solution (valence and arousal or arousal and tension) could be used instead.

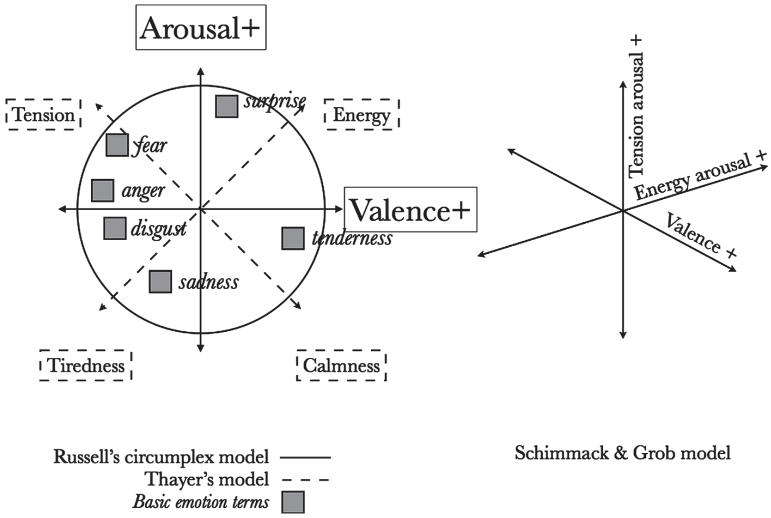

Figure 1. Schematic diagram of the dimensional models of emotions with common basic emotion categories overlaid. Note that the axes of the three-dimensional model are not necessarily orthogonal in actual affect data as depicted here (see Schimmack & Grob, 2000).

Two recent and puzzling findings render the comparison of these conceptual frameworks of emotion even more pressing an issue. Studies with brain damaged patients have documented a dissociation between discrete and dimensional evaluations of emotion in music (Dellacherie, Ehrlé, & Samson, 2008; Gosselin et al., 2005; Khalfa et al., 2008b), implying that separate neural processes are responsible for each of these types of evaluation. Moreover, it has been shown that listeners may experience both sad and happy feelings at the same time when exposed to a stimulus with mixed emotional cues (Hunter, Schellenberg, & Schimmack, 2008). Both of these findings pose challenges for emotion research in music and require a better understanding of the essential similarities and differences between these two conceptual frameworks.

The majority of studies on music and emotions have used excerpts of relatively well-known Western classical music pieces (e.g., Kreutz, Ott, Teichmann, Osawa, & Vaitl, 2008; Krumhansl, 1997; Nawrot, 2003; Schmidt & Trainor, 2001), which have been arbitrarily chosen by the researchers. Other types of musical stimuli used – occasionally together with classical music – include popular music and jazz (Altenmüller, Schuermann, Lim, & Parlitz, 2002; Gomez & Danuser, 2004), film music (Etzel, Johnsen, Dickerson, Tranel, & Adolphs, 2006), music from other cultures (Balkwill & Thompson, 1999; Balkwill, Thompson, & Matsunaga, 2004), and synthetic music that has been composed especially for the research task at hand (e.g., Khalfa, Peretz, Blondin, & Manon, 2002; Vieillard et al., 2008). Well-known music examples are potentially problematic as stimuli because participants may already be familiar with the excerpts. Emotions elicited by this type of stimuli can be closely entwined with extra-musical associations. Synthetic stimuli are free of such problems and have provided opportunities to study and manipulate musical features. However, such stimuli often sound artificial and lack some of real music's intricate features, such as expressive performance and timbre, which might be essential in evoking an emotional response (Juslin, Friberg, & Bresin, 2002; Leman, Vermeulen, De Voogdt, Moelants, & Lesaffre, 2005). Moreover, the stimuli used to investigate dimensional emotion models have typically represented the extremes of the dimensions (e.g., low arousal, high valence) as opposed to points along the continuum of each dimension. This may have led to the neglect of potentially relevant affect data.

It is worth of noting that, with the notable exception of Bigand et al. (2005), musical examples have been chosen solely in terms of wholly discrete emotions (e.g., happy and sad) in the existing studies that use both discrete and dimensional models of emotion in music (Gosselin et al., 2006; Gosselin, Peretz, Johnsen, & Adolphs, 2007; Khalfa et al., 2002, 2008a, 2008b; Kreutz et al., 2008; Krumhansl, 1997; Nyklìcek, Thayer, & Van Doornen, 1997; Terwogt & Van Grinsven, 1991; Vieillard et al., 2008). Hence, the ratings of dimensional concepts such as valence and arousal describe the known points of discrete emotions in the dimensional affective space (e.g., Nyklìcek et al., 1997). However, it is currently unclear what happens in the reverse situation where the musical examples are selected systematically from various points within the affective space. In such cases the discrete emotions may not be easily assigned to examples that are distant from the prescribed point in the affective space for that particular discrete emotion. Lastly, the number of music examples used in previous studies has been relatively low compared with the stimulus sets used by emotion researchers in other fields, such as the visual domain. The International Affective Picture System (IAPS) uses 12 series of 60 pictures each (Lang, Bradley, & Cuthbert, 2005), out of which typical emotion studies tend to use 50–60 images (this was the median in a sample of 20 studies using IAPS). However, in the music domain, much smaller sets are more commonly used.

Aims of the study

The primary aim of the present study is to contribute to the theoretical debate currently occupying music and emotion research by systematically comparing evaluations of perceived emotions using two different theoretical frameworks: the discrete emotion model, and dimensional model of affect. The importance of the comparison lies not only in the prevalence of these models in music and emotion studies, but also in the suggested neurological differences involved in emotion categorization and the evaluation of emotion dimensions (Khalfa et al., 2008b), as well as in the categorically constrained affect space the excerpts have represented to date. Moreover, the various alternative formulations of the dimensional model have not been investigated in music and emotion studies before.

A secondary aim is to introduce a new, improved set of stimuli – consisting of unfamiliar, thoroughly tested and validated non-synthetic music excerpts – for the study of music-mediated emotions. Moreover, this set of stimuli should not only include the best examples of target emotions but also moderate examples that permit the study of more subtle variations in emotion.

Expert selection of the stimulus materials

In order to obtain a large sample of unknown yet emotionally stimulating musical examples, a large expert panel was organized for choosing the material. The primary goal of this panel was to choose emotionally representative musical material from a large selection of film soundtracks according to predefined criteria.

It was decided to use film music because it is composed for the purpose of mediating powerful emotional cues, and could serve as a relatively 'neutral' stimulus material in terms of musical preferences and familiarity. Unfamiliar excerpts were chosen to avoid *episodic memories* from particular films influencing perceived emotions in the music. And yet, since it was film music, and listeners are generally accustomed to this genre from media exposure, the excerpts were nevertheless expected to conjure up *schematic memories*. But this also meant we could not prevent excerpts from triggering memories by simple virtue of them resembling others from a listener's previous experience. With the exception of Vertigo (from 1958), the selection of 60 soundtracks was limited to those published within the last three decades (1976–2006). This was to keep the sound quality of the corpus relatively homogeneous. It should also be noted that the soundtracks came from a wide range of films that included romantic, sci-fi, horror, action, comedy, and drama.

The panel consisted of 12 expert musicologists (staff members and third to fifth year university students) who had all studied a musical instrument for 10 years or more. Each panel member was given five different soundtracks and asked to find five examples of the six target emotions. Half the experts focused on discrete emotions (six targets), and half on the extremes of the three-dimensional model (six targets). For the discrete emotions we chose happiness, sadness, fear, anger, surprise and tenderness, as these have been favoured in previous studies of music and emotion (Juslin, 2000; Kallinen, 2005; Krumhansl, 1997). For the dimensional model, we chose the six extremes of the three-dimensional model of emotion by Schimmack and Grob (2000). This meant the panel should find examples of both positive and negative valence, high and low tension arousal, as well as high and low energy arousal. Each extreme was characterized using three adjectives taken from Schimmack and Grob (2000). For valence, these were pleasant–unpleasant, good–bad, and positive–negative. For the energy dimension the adjectives were awake–sleepy, wakeful–tired, and alert–drowsy. The adjectives used to represent the extremes of the tension dimension were tense–relaxed, clutched up–calm, and jittery–at rest.

To ensure a degree of uniformity in the choice of sound examples, the following criteria were established: each excerpt should be between 10 and 30 seconds (depending on the natural phrasing of the excerpt): it should not contain lyrics, dialogue, or sound effects (car sounds, etc.), and, though familiar with the schematic memory, it should not be familiar in the episodic sense (see earlier). It was also stressed that the goal was to choose examples that could convey the target emotion to the general listener in an optimal way. The experts also made a note of the musical features and devices which informed their choice. This resulted in 360 audio clips ($12 \times 5 \times 6$), equally representative of the discrete emotion and three-dimensional models. Details related to the stimuli (names, ratings, and audio examples) may be found online.[1]

Pilot experiment

The aim of the pilot experiment was to rate all the examples previously selected by experts in terms of both the models (discrete and dimensional). This was done to understand how the emotions were conveyed by the examples. The aim was also to reduce the number of excerpts and homogenize the selection for further investigation.

Method

Participants, stimuli, apparatus and procedure. The participants of the pilot experiment were the same group of experts who originally chose the examples (mean age 24.1 years, SD = 3.9 years, 7 females). The stimuli consisted of all 360 excerpts that had been chosen. The panel then

Table 1. Consistencies, means, standard deviations for all emotion ratings and repeated measures ANOVA results for excerpts grouped by target emotion (η^2 for effect sizes)

Type of excerpt/ concept	Cons. (α) (concept)	Target (concept)	Non-target (concept)	ANOVA (η^2) (excerpts grouped by target)
Happy	.93	5.49 (1.53)	2.02 (0.69)	0.63***
Sad	.89	5.46 (1.60)	2.22 (0.98)	0.71***
Tender	.92	5.69(1.89)	2.38 (0.88)	0.72***
Fearful	.92	5.29 (1.80)	2.63 (0.91)	0.63***
Angry	.92	5.38 (1.61)	2.03 (0.74)	0.69***
Surprising	.66	3.36 (2.05)	1.72 (1.02)	0.23***
Pos. valence	.92	5.68 (0.94)	3.96 (1.00)	0.64***
Neg. valence	–	1.81 (0.68)	4.31 (1.02)	0.88***
Pos. energy	.90	5.67 (0.88)	3.92 (0.96)	0.30***
Neg. energy	–	2.30 (0.77)	4.23 (0.97)	0.58***
Pos. tension	.93	5.98 (0.75)	4.31 (0.86)	0.69***
Neg. tension	–	2.48 (0.90)	4.36 (0.89)	0.68***

Note: *$p < .05$; **$p < .01$; ***$p < .001$; $df = 5{,}179$ for basic emotion concepts, $df = 2{,}89$ for dimensional concepts.

received instructions to rate the *perceived* emotion in each audio clip. Half of them were instructed to rate the discrete emotions on a scale of 1–7 and the rest gave ratings for the three dimensions using bipolar scales. Familiarity with the excerpts was also rated (0 = unfamiliar, 1 = somewhat familiar, 2 = very familiar). Note that each of the panel's own selections constituted a mere 8.3% of the whole material (30 items out of 360). The rating task was also divided into four sections, and between each of them, the emotion models were switched between the two halves of the experts. The sections each consisted of 90 excerpts and lasted about 50 minutes. All the excerpts were played in a random order, but this order was the same for the whole group since it was done as a classroom exercise using high-quality audio in laboratory conditions. In total, the task lasted approximately four hours and was carried out on two separate days. The student participants received course credits for their efforts.

Results

To rule out the order effects, a linear trend analysis was conducted against the rating order for all scales. All the trends yielded non-significant *F*-ratios (*F* values between 0.2 and 2.82, $p = \text{ns}$, df = 358). Next the consensus between the raters was investigated. Cronbach's alpha was employed to measure the consistency between raters, rather than between items, as there was a large proportion of excerpts given similar (low) ratings, which meant negligible item variance. In other words the lowest ratings were given by all raters for those discrete emotions that manifestly did not seem applicable to a particular excerpt, e.g., ratings of sadness for happy excerpts. Most emotion concepts scored relatively high consistency using this procedure, as indicated in Table 1. The notable exception in inter-rater consistencies was surprise ($\alpha = .66$), which was actually unsurprising, as a number of previous studies have also observed this concept to be problematic for music-mediated emotions (Gabrielsson & Juslin, 1996; Laukka & Juslin, 2007). Surprise was therefore eliminated from further analyses, as the alpha for it was considerably lower than for the other emotion terms.

The pilot showed that the raters were not particularly familiar with the excerpts as 89.9% indicated 'unfamiliar', 6.4% 'somewhat familiar' and only 3.8% 'very familiar'. To assess the role familiarity for the emotion categories and dimensions, a variance analysis was conducted using a non-parametric method of calculation (Kruskal-Wallis) as the familiarity ratings contained mainly zeros and were thus not normally distributed (Lilliefors test, $p < .001$). This yielded no significant differences across the discrete emotions, χ^2 (5,179) = 10.18, p = ns, and yet significant differences across the dimensional extremes, χ^2 (5,179) = 30.02, $p < 0.001$. A closer look at the familiarity ratings showed a small number of highly familiar excerpts (above three SDs above the mean familiarity: three in total) in two categories: high valence and low tension. We kept these familiar excerpts in the data set since they represented a minor portion of the total number (0.83%).

Next we explored whether the emotion targets were clearly evident in the ratings. This was done by separately comparing the mean ratings for each type of excerpt using an analysis of variance. This repeated measures ANOVA yielded significant main effects for all of the discrete emotion targets, and with large effect sizes (mostly above 0.60, shown in Table 1). The exception was a surprise, as mentioned previously, which, although statistically significant, exhibited a fairly low effect size. The other weak effect size (0.30) was seen in the ratings of high energy, the reason for which is probably due to its collinearity with the other dimensions. Excerpts representing high energy were also rated high in tension, as well as high in negative valence, and thus the ANOVA results display weaker discrimination between these categories. A post-hoc analysis between the discrete emotion categories (using Holm-Sidak adjusted *t*-tests at $p < .05$ level) revealed this statistically, namely how anger ratings could not be discriminated from fear ratings when anger was the target category. Similarly, ratings of surprise were statistically indistinguishable from ratings of fear and anger. Post-hoc analyses were also used to characterize the differences between dimensional extremes, resulting in statistically significant differences at a level of $p < .05$ in all comparisons.

Discussion

The primary aim of the pilot experiment was to evaluate the chosen set of musical stimuli in terms of two conceptual frameworks in order to establish a systematic basis for selecting the stimuli for the actual experiment. Such selection rationale has been noted to be largely absent in the previous studies of music and emotions (Juslin & Västfjäll, 2008). The chosen target emotions were clearly evident in the ratings, with the exception of surprise as previously noted, and so this was removed. As the set of stimuli contains a large variety of music excerpts rated in terms of both emotion models, it is now possible to compare these models in a theory-based and systematic way.

Experiment

The first aim of this experiment was to systematically compare the effectiveness of discrete and dimensional models in the study of perceived emotions in music. A related aim was to explore whether some of the ways of representing emotions within the discrete and dimensional models could be merged or eliminated (e.g., collapsing the three-dimensional model into two dimensions, or removing some of the overlapping concepts from the discrete emotion model).

The second aim was to form a refined set of musical examples, which would not only include the clearest exemplars of the discrete emotion categories, but also ones that are less easily attributable to a category. Such moderate examples would provide more realistic and interesting material for empirical work on recognition and induction of emotions in music than the standard paradigm, where only a few highly characteristic examples of emotion categories are used. An experiment was designed to address these questions using a subset of the stimuli from the pilot experiment.

Method

Stimuli. To validate the stimulus material and to compare the conceptual frameworks, stimuli were needed to represent emotion concepts from both discrete and three-dimensional models in order to do justice to both (see Mikels et al., 2005 for a selection method aimed at discrete emotion categories). Therefore, a sampling of the 360 excerpts from the pilot experiment using both models was carried out. In the first stage, all excerpts that were rated as moderately or very familiar in the pilot experiment were eliminated. To obtain both highly and moderately typical examples of discrete emotions, it was necessary to calculate the *typicality* (T) of the target emotion for each excerpt (i). This was done by subtracting the mean of the excerpt's non-target emotion rating ($N\overline{E}_i$) and the standard deviation of its target emotion rating (SE_i) from the mean of the target emotion rating ($\overline{E}_i$)

$$T_i = \overline{E}_i - SE_i - N\overline{E}_i$$

Highest typicality values for excerpts occurred when they were highly and consistently rated on the target emotion, and *not* attributed to other emotion categories. For example, two excerpts scoring 6 on sadness had a different typicality value if they differed in consistency and their scores for other emotion categories. If a sadness rating had a mean of 6 with a SD of 2, and a mean of 1 in other emotion categories, it would result in a typicality of 3 (6–2-1). However a mean sadness of 6 with more deviation, and therefore less consistency (SD 3), together with higher attributions to other categories (1 in fear, anger, surprise, and happiness but 5 in tenderness, which is a $N\overline{E}_i$ of 1.8) would have a typicality of only 1.2 (6–3-1.8). The excerpts were thus ranked according to their typicality values for each emotion. From these ranked lists, the top five examples were chosen as best examples of each discrete emotion (happiness, sadness, tenderness, anger and fear), called high examples hereafter. Five moderate examples were taken from the ranked positions of 51 to 55 of each similarly ranked list. This yielded a total of 50 examples for all the discrete emotions ([5 high + 5 moderate] × 5 categories). Surprise was not incorporated into this experiment due to the low consistency and recognition it received in the pilot experiment.

For the dimensional model, another scheme for obtaining representative examples from the pilot experiment was adopted. Each dimension was sampled at points along its axis whilst the other two dimensions were kept constant. The purpose of this was to maximize the variance according to the dimension in question, although this was not always entirely possible due to the collinearity of the dimensions. The axis of each dimension was then split into four percentiles as follows: extreme low (< 10%), moderate low (20%–40%), moderate high (60%–80%) and extreme high (> 90%). From each of these percentiles five excerpts were taken, which meant a total of 20 for each dimension, exhibiting a similar range of typicality. During this process, the other two dimensions were kept in control by minimizing the error distance so that the excerpts were chosen as close to the target dimensional axis as possible. In this way 60 audio clips (4 × 5 × 3) were picked to cover the essential variance of the three-dimensional affect space. Again, the purpose of choosing examples that were only moderate examples of the target emotion concept was to increase the coverage of the stimulus space, and to compare the effectiveness of each model at rating ambiguous excerpts. In the case of the dimensional model, we also wanted to provide stimulus material which could be used to test whether the conceptual framework does actually operate in a dimensional fashion which is otherwise hard to do if only best examples of the bipolar extremes are used. A list of the final stimuli may be found in the Appendix, and the details are also documented online[2] (50 discrete + 60 dimensional = 110 examples in total).

Participants. The participants for the main experiment were 116 university students aged 18–42 years (mean 24.7, SD 3.75, 68% females and 32% males). Forty-eight percent of the participants did not play any instrument and were not musically trained, 41% had experience of playing an instrument or some level of musical training, and 11% were in between with music as a hobby for less than three years. The participants received cinema tickets in return for their participation, and a number of individual variables were collected from each of them. First, a survey of their musical taste was made using a localized version of the STOMP questionnaire (Rentfrow & Gosling, 2003). Second, their current mood at the time of taking the test was evaluated using the POMS-A questionnaire (Terry, Lane, Lane, & Keohane, 1999). Third, an assessment was made of the participants' personality traits using a 44-item personality measure known as 'The Big Five Inventory' (John & Srivastava, 1999). And finally a short questionnaire was given out to gather information about the participants' film genre preferences, musical training, and any hearing problems.

Procedure. The experiment was divided into two blocks: block A with the 50 discrete emotion excerpts and block B with the 60 dimensional model excerpts. The order of the blocks was counterbalanced across the participants (67 participants did block A first followed by block B), and the order of the examples within blocks was individually randomized. The participants were instructed to rate the emotions represented by the music excerpts (perceived emotions), and the difference between perceived and induced emotions was explained to them. While one group of participants were rating excerpts in block A on a scale of 1–9 for each discrete emotion, the other group was rating excerpts on bipolar scales of 1–9 for each of the three axes of the dimensional model. Then the blocks were switched for each group. This meant that the experiment used both models to rate the emotions in all 110 excerpts without taking an unreasonably long time. The total duration of the experiment was between 50 and 60 minutes, depending on the participant's rating speed.

Participants were also asked to mark how much they liked each example (with a preference rating) and how beautiful they considered each example to be (with a beauty rating). In both cases this was on a scale from 1 to 9. These additional measures were added to clarify the role of valence because valence and preference have been shown to be separate constructs (Schubert, 2007). For example, one can be fond of harsh and rough sounding music despite the fact that most people associate those qualities with negative valence. Ratings of preference and beauty would also briefly allow the exploration of the relation between sadness and valence in this context.

Before the actual experiment, a short practice session was carried out by each participant to become familiar with the interface, likert scales, and type of music used. The participants also had the possibility to ask questions about the task before the start of the experiment.

Apparatus. The listening experiments were conducted in a soundproof room. To gather the emotion ratings, a special patch was designed in *Pure Data* graphical programming environment (Puckette, 1996), running on Mac OS X. The patch enabled the participants to move from one excerpt to the next at their own pace and to repeat an excerpt if needed. Participants listened to the excerpts through studio quality headphones (AKG K141 Studio), and were able to adjust the sound volume according to their own preferences.

Results

To rule out extreme mood states that might affect the participants' emotion ratings, POMS-A ratings were aggregated and the distance from the mean rating (1.87, SD = 0.47 on a scale of 1–5) was calculated for each participant. One participant whose score was more than three SDs above the mean was removed from the analysis as that person's current mood appeared considerably pessimistic, tired and negative. The intersubject correlations were used to identify possible outliers and anyone who scored more than three SDs from the mean intersubject correlation was removed from the dataset. This resulted in the removal of five participants, leaving the total of 110 that was eventually used. Cronbach's alpha was used to assess the inter-rater reliability across both experimental blocks. All emotion ratings received alphas above .99 and only the preference ratings were slightly lower (.94), probably since personal opinions are prone to vary across individuals. Subsequently the data was pooled together for further analyses.

We reviewed the contribution of individual variables (personality, musical preferences, film genre preferences, and musical training) to the emotion ratings by correlating the individual ratings with the background variables. Only a few statistically significant correlations emerged: the personality trait 'openness to experience' (John & Srivastava, 1999) appeared related to increased ratings of anger ($r = 0.25$, $p < .05$) and valence ($r = 0.33$, $p < .05$), and 'extroversion' seemed related to decreased ratings of tension ($r = -0.38$, $p < .01$). These traits may therefore indicate different rating strategies. 'Negative mood' (POMS-A; Terry et al., 1999) was, perhaps unsurprisingly, related to increased ratings of sadness ($r = 0.29$, $p < .05$). These initial observations are potentially interesting and are known to influence emotional evaluations (Kreutz et al., 2008; Rusting, 1998), but the figures indicate that their role is only moderate at best, and thus these factors will be left unexplored at this stage.

Discrimination of emotion categories and levels. An examination of the discrete emotion rating was carried out next using a mixed design repeated measures ANOVA for groups of excerpts representing each target emotion. The five emotion concepts (anger, fear, sadness, happiness, and tenderness) as the within subjects variable. The two levels (high and moderate) at which excerpts conveyed an emotion (i.e., high and moderate examples) provided the within group variable. Taken together this gave significant main effects for all target emotion concepts, and a significant main effect for levels in one target emotion. There was also significant interaction effects between these two factors in four of the target emotions (see Table 2 for effect sizes and *p* values). In other words, the effect sizes were robust for concept (between 0.79 and 0.83; see Table 2), but negligible for emotion levels (0.000–0.006). And most of the interactions between concept and level were within each target emotion were significant. These analyses were later followed by post hoc tests, in which *p* values were adjusted using the Holm-Sidak procedure to avoid the effects of multiple comparison tests (Ludbrook, 1998). These analyses revealed that in the high examples the target emotion was never confused with other emotion concepts, but the moderate examples exhibited confusions between one or two other concepts of emotion (see Table 2). Figure 2 clearly shows this pattern. For example, moderate examples of anger are indistinguishable from fear and sadness, and moderate examples of tenderness could easily be

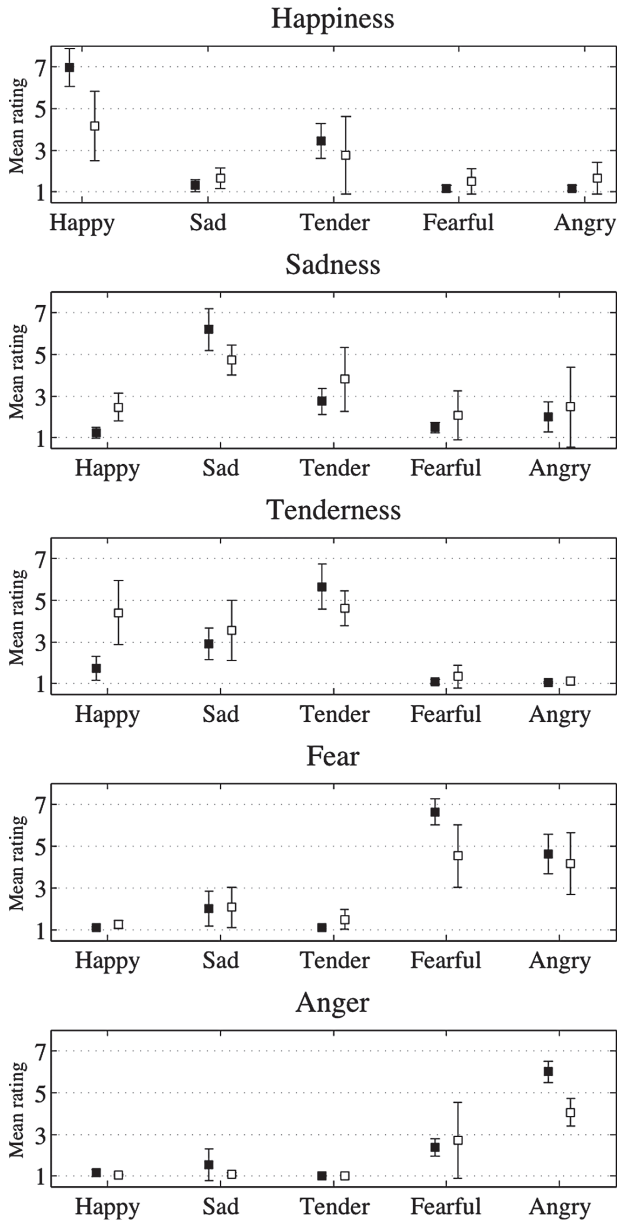

Figure 2. Mean ratings and 95% confidence intervals for five discrete emotions and 50 excerpts representing these target emotions (black markers for high examples and white for moderate examples).

Table 2. Mixed-design repeated measures ANOVA results for groups of excerpts representing each target emotion (η^2 for effect sizes). Post-hoc tests display target emotions that do not reliably differ in means (using Holm-Sidak adjusted values for $p < 0.05$)

Type of excerpt	Category	Level	Interaction	Post-hoc (moderate)
Happy	0.70^{***}	0.003^{**}	0.21^{***}	S, T
Sad	0.83^{***}	0.003	0.05^{*}	T
Tender	0.78^{***}	0.000	0.05	H, S
Fearful	0.79^{***}	0.001	0.08^{**}	A
Angry	0.79^{***}	0.006	0.06^{**}	F, S
Pos. valence	0.52^{***}	0.01	0.08^{*}	En, Te
Neg. valence	0.70^{***}	0.000	0.08^{*}	En, Te
Pos. energy	0.44^{***}	0.11^{*}	0.06	Va, Te
Neg. energy	0.54^{***}	0.01	0.11^{*}	Te
Pos. tension	0.81^{***}	0.02^{**}	0.07^{*}	En
Neg. tension	0.58^{***}	0.09^{*}	0.03	En

Notes: $p < .05$; $^{**}p < .01$; $^{***}p < .001$; $df = 4,49$ for basic emotion concepts, $df = 2,29$ for dimensional concepts.
S = Sadness, T = Tenderness, H = Happiness, A = Anger, F = Fear, Va = Valence, En = Energy, Te = Tension.

confused with happiness and sadness (the precise confusion pattern is given in the last column of Table 2). The effect sizes and patterns of confusion are similar to the ones observed in the pilot experiment, and confirm prior research (e.g., Gabrielsson & Juslin, 1996).

Similarly for dimensional examples, mixed design repeated measures ANOVAs were carried out to investigate how ratings for each group of excerpts representing different target emotions varied between the dimensions and levels within that dimension. This was done in the same way as with the discrete emotion examples. Table 2 and Figure 3 display the results of this analysis, which yielded significant main effects for the concept and significant effect for level in three of the dimension extremes. There was also a significant interaction effect between concept and level for four of the dimension extremes. The effect sizes were comparable to those obtained with discrete emotions (between 0.44 and 0.81 in the concept effect sizes and between 0.00 and 0.11 for the level effect sizes). As with the discrete emotion examples, Holm-Sidak adjusted post hoc analyses were also performed (results shown in the last column of Table 2). However, the results have to be interpreted in a different manner since the ratings given with the three-dimensional model only indicate the excerpt's location in the dimensional space.

Reliability of discrete and dimensional model ratings. Although the overall reliability of the dimensional and basic emotion model scales was earlier found to be high, a closer scrutiny may reveal interesting differences, especially related to numerous ambiguous (moderate) examples. To compare the applicability of the discrete and dimensional models in the rating of emotionally ambiguous as well as highly characteristic excerpts, the raw ratings for the high examples of target discrete emotions were compared with the raw ratings for moderate examples of target emotions. This was done using inter-rater agreements across the excerpts (Cronbach's alpha). The agreements within the high and moderate examples of target emotions were different, $\alpha = .74$ for high and $\alpha = .49$ for moderate examples. To evaluate the statistical significance of this difference, we used bootstrapping, in which the confidence intervals (CI) of the statistics in question were obtained for 1,000 bootstrapped calculations (Davison & Hinkley, 1997). On the basis of these confidence intervals, the means were found to be different at $p < .001$ level (mean

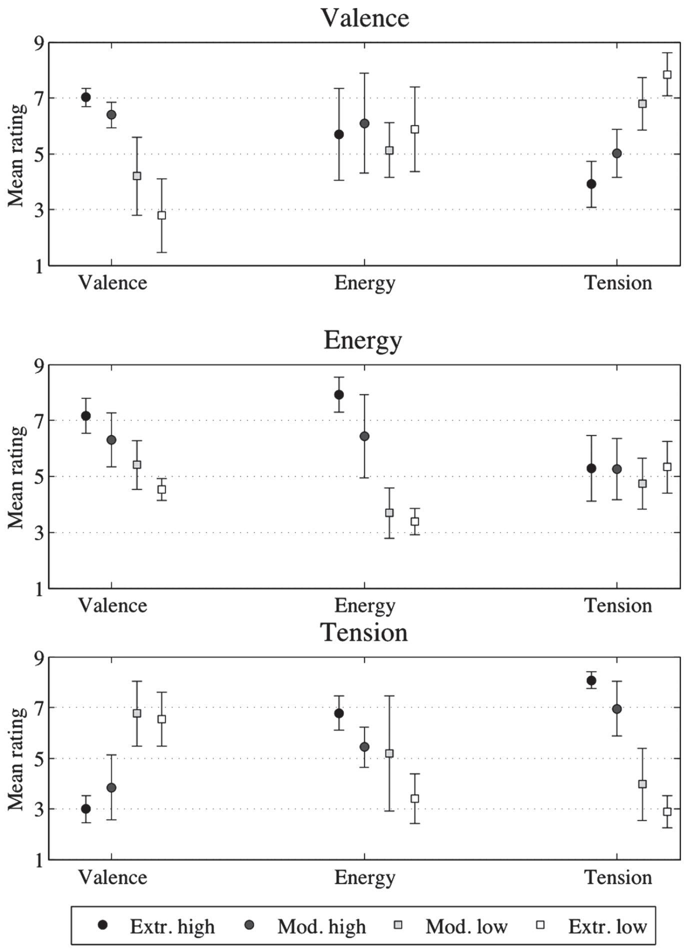

Figure 3. Mean ratings and 95% confidence intervals for 60 examples representing 6 target emotions and 2 levels of the three dimensions.

$_{CI\ 99.9\%}$ for high examples was .74 $_{.69\ .78,}$ and for moderate examples it was .49 $_{.29\ .61}$). Similar analysis was performed for the raw ratings of the three dimensions, and the resulting reliability estimates were also significantly different at $p < .001$ level (mean $_{CI\ 99.9\%}$ for high examples was .95 $_{.94\ .96}$ and for moderate examples it was .77 $_{.72\ .82}$). Although the reliabilities for both models show significantly lower overall reliabilities for moderate excerpts, presumable as they may be a mixture of several emotions, those for moderate excerpts from the dimensional model are at the same level as the reliabilities for the high excerpts of the basic emotion model, implying a higher overall reliability in the dimensional model ratings. However, perhaps the selection of the basic emotion excerpts is such that they have lower overall reliability in general compared with the dimensional model excerpts and the difference is not in the measurement model. To evaluate this argument, we replicated the same analysis but reversed the concepts (high examples of target emotions selected using the basic emotion model were rated with the dimensional model). The reliabilities and their confidence intervals showed again a similar pattern. For basic emotion model ratings of the dimensional targets, α was $.87_{.85\ .89}$ for characteristic examples, and $.70_{.66\ .74}$ for ambiguous examples. For dimensional model ratings of the basic emotion model targets, the alphas were higher ($.94_{.93\ .95}$ for high examples, and $.85_{.81\ .87}$ for moderate examples). In both cases, significant differences in the reliabilities between the high and moderate excerpts were found but the overall reliability of the dimensional ratings was again higher. So the dimensional model provides somewhat higher inter-rater consistency no matter which way the musical excerpts have been chosen. Whether consistency is a crucial detail in assessing the adequacy of these models is another question. High consistency could for example also indicate that the measurement scale is trivial and thus offers little insight into the actual emotion process.

The applicability of the discrete emotions to the appropriate emotion prototype areas (Russell & Feldman Barrett, 1999) is visualized in Figure 4, where both the strength and the variation of all discrete target emotions are shown as densities in the valence-energy space. Marked in the plot are the target centroids of the chosen high and moderate examples of the five discrete emotions, which indeed lie in the approximate (attractor) areas of high ratings for these emotions. Moreover, the variation demonstrates that the high examples are mostly located within areas of high agreement (sadness and tenderness are the notable exceptions), and the most moderate examples are located in less well-defined areas. In contrast, the deviations in the ratings of the dimensional model are lower and spatially more uniformly distributed, and do not have such ill-defined areas around the attractors of the emotion categories. This is also demonstrated by the means of the ANOVA above. The practical implication of this is that, whereas both models may be used to adequately describe emotional excerpts representing clear examples of discrete emotions, the strength of the dimensional model lies in its ability to describe such emotional examples that lie outside these discrete attractor areas. The utilization of this asymmetry between the models would allow us to explore how a hybrid model of emotions might manifest itself in music (Russell, 2003), and is of consequence to clinically oriented studies that are interested in the patients' processing of emotionally ambiguous examples (e.g., Bouhuys, Bloem & Groothuis, 1995; Cavanagh, & Geisler, 2006).

In the end participants were able to recognize the target emotions represented by the high examples consistently, and in moderate examples the target emotion was confused with at least one other emotion. This has also been observed in previous research, and could be interpreted more generally as fuzziness in the definition of the emotion categories (for examples, see Dailey, Cottrell, Padgett, & Adolphs, 2002; Russell & Fehr, 1994). In the case of the emotion dimensions, the results have to be viewed from a different angle, because here the 'emotion targets' were actually the six bipolar extremes of three dimensions. Instead of concentrating on the confusion between different dimensions, we should focus our attention towards any possible confusion between the bipolar extremes of a given dimension. For example, valence and tension ratings for excerpts representing moderate positive energy did not differ (see Table 2). To set these observations into a wider context, it is necessary to examine the whole pattern of correlations between the emotion concepts.

Patterns of correlations between the emotion concepts. Our intention was to explore how the two dominant conceptual frameworks for emotions in music (dimensional and discrete) can be used

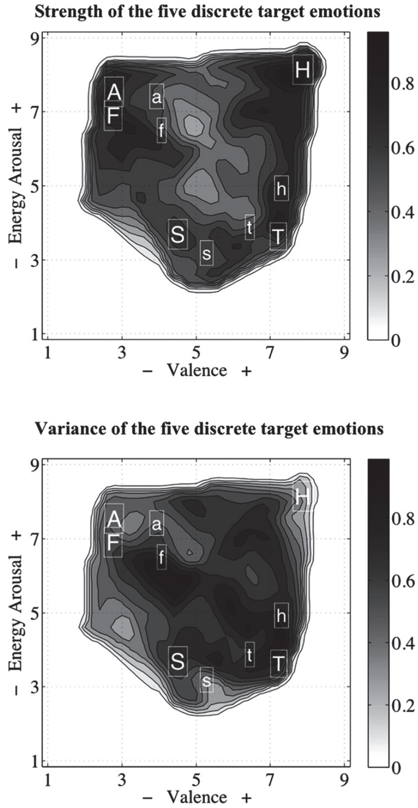

Figure 4. The intensity of each discrete target emotion is shown via accumulated density distribution of the emotion ratings for each category (upper panel). To define each of the five discrete target emotions, the examples that received ratings above the upper 50% percentile of the appropriate target ratings have been selected. The labels refer to the centroids in the valence–arousal space defined by the five discrete target emotion examples (A = anger, F = fear, H = Happiness, T = tenderness, and S = sadness, capitals refer to high examples and small letters moderate examples). The lower panel displays a similar projection of discrete emotion areas within the valence – arousal space, but the gradient indicates the amount of variation (normalized standard distribution of the ratings) for each emotion category. The centroids of the high examples are located clearly on well-defined areas (high intensity and low deviation) whereas the moderate examples are on less clearly defined areas (lower intensity and higher variation).

to describe perceived emotions in music. We also set out to clarify what type of dimensional model would be the most appropriate for such studies. To make this comparison we used a variety of correlational techniques. To begin with, mean ratings for both sets of stimuli were visualized across the three dimensions (Figure 5) and the ratings of the discrete emotion categories were indicated with appropriately sized markers (the greater the marker size, the greater the

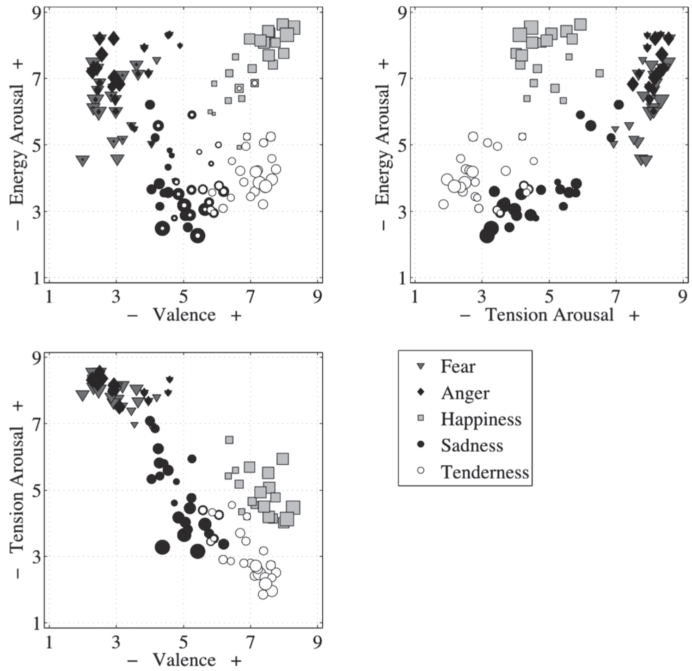

Figure 5. Mean ratings of three dimensions and discrete emotions for all excerpts (N = 110). The marker types represent the target emotion categories and the sizes indicate the mean target emotion rating for each excerpt.

mean rating for the discrete emotion indicated by the marker type). The scatterplots in Figure 5 show a highly collinear structure between valence and tension. However, the remaining dimensions display less evident correlational structures. The discrete emotion categories – as represented by marker types and sizes – suggest a clear separation of happy excerpts from the rest of the discrete emotions. Also tenderness and sadness stand out as distinct areas within the dimensional space. None of these three categories overlap with anger and fear, even if these two do so between themselves in the dimensional structure (see Kreutz et al., 2008; Schubert, 1999; Vieillard et al., 2008). As we remember from the analysis of discrete emotion ratings, this overlap was also evident in the ratings of anger and fear, and thus is not a feature particular to the dimensional emotion model alone.

Correlations between the different emotion concepts, together with preference and beauty, are shown in Table 3. Fear and anger can be observed to correlate highly with each other ($r = .69$, $p < .001$), which suggests that these two emotion concepts might not be easily distinguishable in the context of music (Juslin, 2000; Kallinen & Ravaja, 2006). Interestingly, tenderness received higher correlations with sadness ($r = .36$, $p < .001$) than with happiness ($r = .15$), as traditionally tenderness has been associated with positive emotions in general (Juslin, 2001, p. 315). Another noteworthy observation is that valence and sadness did not correlate with each other. This is in line with results obtained by Bigand et al. (2005) and Kreutz et al. (2008), who both discovered that sad music was not systematically associated with negative valence. Although sadness is generally considered to be an unpleasant emotion, the classification is not as straightforward in the context of music. For instance Schellenberg and colleagues (2008) found that, in some instances, sad music was liked as much as happy music. It seems that in music-mediated emotions, happiness and sadness do not represent the opposite extremes of valence: although happiness had a strong positive correlation with valence ($r = .80$, $p < .001$), sadness and valence did not correlate ($r = -.03$). Sad music is often considered beautiful, and therefore it may be difficult to perceive sadness in music as unpleasant. Schubert (1996) has offered a theoretical solution to this dilemma using a neural inspired associative network model, in which negative emotions in an aesthetic context may activate enjoyment. In fact, it has even been reported that sad music activates neural networks involved in biological reward (Blood & Zatorre, 2001). For example, sadness correlated with preference ($r = .38$, $p < .001$) and beauty ($r = .59$, $p < .001$) significantly more highly than happiness ($r = .22$, $p < .05$; $r = .16$). However, tenderness and valence correlated with preference ($r = .58$, $p < .001$; $r = .56$, $p < .001$) and beauty ($r = .77$, $p < .001$; $r = .61$, $p < .001$) even more highly than sadness. Lastly, the ratings given by the participants in the main experiment were to a great extent similar to the ratings given by the small group of experts in the pilot (the final row in Table 3).

When comparing our results to earlier studies of the three-dimensional model (conducted in non-music contexts) we find there are certain differences, particularly when the correlations between separate dimensions of the models are taken into account. For example, in a study based on current mood ratings, Schimmack and Grob (2000) found a strong positive correlation between energy and valence ($r = .49$), a strong negative correlation between valence and tension ($r = -.70$), and a moderate negative correlation between tension and energy ($r = -.33$). In our study, energy and valence did not correlate with each other ($r = -.08$), valence and tension had a very strong negative correlation ($r = -.83$), and tension and energy had a strong positive correlation ($r = .57$). This might be due to the different qualities of music-mediated emotions compared to mood or everyday emotions, but there are no other points of comparison from the field of music-mediated emotions. Another possible cause for the difference is that, despite our efforts of sampling the three-dimensional space in a systematic manner, the chosen sound examples may have represented the geometric space in a different way to how it was

Table 3. Correlations between the concepts ($N = 110$).

	Happiness	Sadness	Tenderness	Fear	Anger	Valence	Energy	Tension	Pref.
Sadness	−.48***								
Tenderness	.15	.36***							
Fear	−.61***	−.28**	−.67***						
Anger	−.41***	−.31**	−.58***	.69***					
Valence	.80***	−.03	.63***	−.91***	−.71***				
Energy	.44***	−.79***	−.64***	.28***	.47***	−.08			
Tension	−.42***	−.38***	−.87***	.87***	.75***	−.83***	.57***		
Pref.	.22*	.38***	.58***	−.63***	−.37***	.56***	−.31***	−.63***	
Beauty	.16	.59***	.77***	−.73***	−.56***	.61***	−.58***	−.81***	.87***
Experts†	.94***	.88***	.90***	.93***	.92***	.86***	.90***	.94***	

*Notes:**** $p < .001$; ** $p < .01$; * $p < .05$; †Correlation with the ratings of the experts from the pilot experiment for the same 110 excerpts.

represented in the previous studies. For instance, we have relatively few examples of excerpts representing low tension and negative valence, as the correlations suggest that these variables mostly co-varied. At this point it is difficult to conclude whether this phenomenon is specific to music or the particular set of stimuli we used, as we do not have alternative samples of stimuli at our disposal. Nevertheless these correlations, as well as the figures, hint at a possible reduction of the three-dimensional model. We will address this issue after first making a direct comparison of the discrete and dimensional approaches.

Correspondence between discrete and dimensional models of emotions. To assess the compatibility of the two main conceptual frameworks for emotions in music, we adopted two correlational techniques, canonical correlation and regression. In the canonical correlation, the interdependency of the two frameworks could be measured in a single analysis. This analysis provided three canonical variates. The first canonical correlation was .99, the second .94 and the third was .57, and the model with the three canonical correlations included was highly significant, χ^2 (15) = 634.05, $p < .0001$. The first three pairs of canonical variates accounted for a significant relationship between the two sets of variables. Data on the canonical variates are displayed in Table 4. Indicated in the table are correlations between the variables and canonical variates, within-set variance accounted for by the canonical correlations (percent of variance), redundancies and canonical correlations. Total percentage of variance indicates that the third canonical variate was minimally related to the two sets of variables and therefore the interpretation of the third pair is questionable, even though this variate was also statistically significant ($\chi^2 = 41.80$, $p < .001$). The interpretation of the first canonical variate can be drawn from the correlations, indicating that the variate may be labelled as valence (inverted). This is because tension (.88), fear (.94) and anger (.75) as well as valence (–.98) are projected with high loadings onto the first variate. The second canonical variate could then be labelled as activity (inverted). This is because energy (–.92), happiness (–.64), and sadness (.85) receive the highest correlations with the second canonical variate. The interpretation of the third canonical variate is precarious due to the low percent of variance that can be explained (0–5%). This analysis as a whole puts forward the notion that the two conceptual frameworks are largely similar and the minimal description of this mapping might reasonably have a two-dimensional structure.

In the second conceptual comparison, we employed regression to predict the dimensional ratings from the discrete ratings and vice-versa. This technique has the advantage of providing a well-known measure of fit (R^2). As all 110 music examples were rated using both conceptual frameworks, such a comparison was possible. Knowing that relatively high correlations exist between the emotion ratings, collinearity of predictors was evaluated using a variance inflation factor (VIF) for each set of predictors (basic emotion and dimensional models). For basic emotion ratings, all VIF values remained lower than the suggested threshold value for collinearity (10; see Cohen, Cohen, West, & Aiken, 2003, p. 423) but for valence, energy arousal and tension arousal, VIF values indicated high collinearity (11.4, 5.3, 16.9). For this reason, the regression estimates for each basic emotion concept with the dimensional model ratings as predictors was performed using ridge regression. This technique is less influenced by collinearity due to the inclusion of constant variance parameter (λ), which attenuates the influence of collinearity in the calculation of the least squares optimization in regression (Cohen et al., 2003). In this case, optimal λ was set at 50 (three predictors) and 100 (two predictors), which was established by 10-fold-over cross-validation with this data. The results – displayed in Table 5 – demonstrate that the discrete emotion model can more accurately explain the results obtained with the three-dimensional model than vice-versa. This may partly be due to the higher amount of explanatory

Table 4. Correlations, canonical correlations percents of variance and redundancies between dimensional and categorical ratings and their corresponding canonical variates

	1st Can. Var.	2nd Can. Var.	3rd Can. Var.
Dimensional			
Valence	–.98	–.11	.04
Energy	.20	–.92	–.03
Tension	.88	–.37	–.13
Percent of variance	.59	.33	.00
Redundancy	.57	.29	.00
Categorical			
Happiness	–.75	.64	.05
Sadness	–.07	.85	.05
Tenderness	–.71	.53	.33
Fear	.94	–.11	.94
Anger	.75	–.37	.42
Percent of variance	.51	.31	.06
Redundancy	.49	.30	.05
Canonical correlation	.99	.94	.57

variables (five) but also the fact that discrete emotions are an easier concept for the general public to understand than emotion *dimensions*. Nevertheless, the difference between the mean prediction rates of the models (displayed in Table 5) is not large (17%) and this considerable degree of overlap between the conceptual frameworks is noteworthy considering that neurological evidence has suggested that separate processes might be involved (Dellacherie et al., 2008), and that it is only relatively recently that both models have started to occur within the same study.

To examine the validity of the three-dimensional model, the coefficients of determination for it were also compared with the circumplex model (Russell, 1980) and the multidimensional model of activation (Thayer, 1989). The results suggest that these two-dimensional models can explain the results obtained with the discrete emotion model virtually as accurately as the three-dimensional model, with the exception of anger (see Table 5). The differences between the prediction rates of the three alternative dimensional models were evaluated using a comparison of the difference between two multiple correlations (Steiger, 1980), which involves transforming the multiple correlations of the predicted models into Z scores and adjusting for mutual correlation and sample size (Tabachnick & Fidell, 2001, p. 146). This analysis yielded significant differences between all the different prediction rates of the models (see Table 5). It is worth pointing out that, in comparison to other emotion categories, sadness was explained equally modestly ($R^2 = .63$) by all dimensional models. This may reflect the participants' difficulty with rating the valence of sad music, as previously mentioned. Despite this irregularity, these analyses suggest fairly high mutual correspondence between the two conceptual frameworks and stimulus sets, and further suggest that the common denominator between these frameworks might be two-dimensional.

A requisite number of dimensions. The previous summary of the correlations between the emotion ratings suggested high collinearity within the three-dimensional model (the overlap between valence and tension). To examine whether the three-dimensional model could be reduced to two dimensions, the independence of the three dimensions needed to be scrutinized.

Table 5. Regression summary of dimensions and discrete emotions explaining discrete and dimensional emotion ratings ($N = 110$)

	R^2 (β)		
	3D	2D (Russell)	2D (Thayer)
Dimensions as predictors (valence, energy, tension)			
Happiness	.89 ($V_{0.93}$, $E_{0.79}$, $T_{-0.35}$)*	.89 ($V_{0.85}$, $E_{0.49}$)*	.86 ($E_{0.64}$, $T_{-0.62}$)
Sadness	.63 ($V_{-0.20}$, $E_{-0.84}$, $T_{-0.22}$)	.63 ($V_{-0.05}$, $E_{-0.69}$)	.60 ($E_{-0.65}$, $T_{-0.13}$)
Tenderness	.77 ($V_{0.33}$, $E_{-0.45}$, $T_{-0.58}$)**	.74 ($V_{0.50}$, $E_{-0.51}$)	.77 ($E_{-0.34}$, $T_{-0.61}$)**
Fear	.87 ($V_{-0.83}$, $E_{0.07}$, $T_{0.63}$)**	.87 ($V_{-0.90}$, $E_{0.24}$)**	.74 ($E_{0.03}$, $T_{0.85}$)
Anger	.64 ($V_{-0.52}$, $E_{0.32}$, $T_{0.35}$)**	.68 ($V_{-0.55}$, $E_{0.35}$)**	.54 ($E_{0.22}$, $T_{0.52}$)
Mean R^2	.76	.76	.70
Discrete emotions as predictors (happiness, sadness, tenderness, fear, anger)			
Valence	.97 ($H_{0.35}$, $S_{-.11}$, $T_{0.20}$, $F_{-0.50}$, $A_{-0.14}$)		
Energy	.88 ($H_{0.47}$, $S_{-0.32}$, $T_{-0.42}$, $F_{-0.05}$, $A_{0.36}$)		
Tension	.93 ($H_{-0.29}$, $S_{-0.23}$, $T_{-0.55}$, $F_{0.18}$, $A_{0.12}$)		
Mean R^2	.93		

Notes: β = Standardized beta coefficients. For predicting basic emotions with emotion dimensions, ridge regression was used ($\lambda = 50$ for 3-dimensions, and $\lambda = 100$ for 2-dimensions). For all models, F tests were significant at $p < .001$. Asterisks denote significant difference between the regression models within each categorical emotion (** at $p < 0.01$ level; * at $p < 0.05$ level).

For instance, Roberts and Wedell (1994) have aptly demonstrated that the amount of dimensions needed to explain common mood terms is influenced by stimulus density. In their study, the common two-dimensional solution (valence and arousal) was not sufficient when a core set of mood terms were supplemented with terms representing variants of anger and fear. In the present study, two different types of reductions could be attempted: energy and tension dimensions could be collapsed into one arousal dimension (Russell & Feldman Barrett, 1999) or energy and valence, and tension and valence could both be collapsed into separate dimensions, forming another two-dimensional construct (Thayer, 1989). The plausibility of these more parsimonious models could be investigated by looking at the partial correlations between the dimensions or by testing these explicitly with separate structural equation models. However, when the intercorrelation between the model predictors is high (> .85), it is known to pose severe problems for such iterative models that are based on a covariance matrix (Kline, 2004). Therefore we resorted to a simpler strategy and looked at the partial correlations.

To investigate reducing three dimensions into the traditional two dimensions of valence and arousal (Russell, 1980), we checked whether tension and energy, which correlate positively (.57), could be collapsed into a single arousal dimension by partialling out the contribution of the valence dimension. This analysis yielded a partial correlation of $r_{te.v} = .90$ ($p < .001$), indicating a considerable overlap between the concepts. As valence and energy did not correlate significantly (–.08), we consequently received support for the traditional two-dimensional model. Note that this is in contrast to the results obtained by Schimmack and Reizenstein (2002), who used structural equation modelling to test the independence of the energy and tension dimensions by controlling for valence, and they found no correlation between the residuals of the energy and tension dimensions.

The other two-dimensional model (Thayer, 1989) casts valence into two separate dimensions that consist of energy and tension. As we know from the first order correlations, valence and tension correlate highly ($r = -.83$), but if we control for the contribution of energy then this high correlation might be revealed to be spurious. Nevertheless, valence and tension correlate even more highly when the energy ratings are partialed out ($r_{vt.e} = -.95$), suggesting that at least the high collinearity is not affected by the energy dimension. Partialling out the tension from the correlation between energy and valence also makes them correlate even more highly ($r_{ev.t} = .85$), lending further support for the possibility of dimensional reduction. In sum, both theoretically derived ways of reducing the three dimensions into two are supported by these analyses although the difference between the two reductions is not discernible.

A requisite number of emotion categories. We may also ask whether the ratings of the five discrete emotions contain significant overlap. In comparing conceptual frameworks using regression, we already observed that three to five discrete emotions were necessary to explain over 90% of the ratings in three dimensions. We also noticed how fear and anger seemed to overlap ($r = .69$) when looking at the first order correlations. Here we looked again at the partial correlations by controlling the contribution of the other three discrete emotions while examining the correlation of each pair of discrete emotions. Table 6 displays the results of such analysis. The most striking partial correlations can be seen between happiness, sadness, and fear, all negative and highly significant. This implies that if we removed the ratings of happiness from the data, we would still be able to deduce that happy examples are those which are rated low on sadness, anger, and fear. The case of fear is more complicated, however, as it correlates with sadness and tenderness and so its removal could not be entirely constructed from the three other remaining discrete emotions. Interestingly, fear and anger do not correlate with each other when the other discrete emotion categories are partialled out. It seems that the contribution of happiness ($r_{fa.h} = .60$, $p < .001$) and sadness ($r_{fa.hs} = .18$, $p =$ ns) is enough to create this effect. Thus, the overlap between happy and sad examples indicates that the real simplification of the discrete emotion model may be in terms of the valence dimension. From the previous canonical correlation and regression analysis we already know that this is a viable way of reducing the number of variables in question. Nevertheless, the issue needs to ultimately be considered in a larger context where the purpose of the measurement model can be taken into account.

Discussion

The results of the experiment suggest that the three-dimensional model of emotions may be collapsed into a two-dimensional one when applied to music. The support for this interpretation comes from (1) canonical correlations that highlighted two canonical variates which could account for the correspondence between the discrete emotion and dimensional models, (2) regression analysis which demonstrated that the ratings of discrete emotions may be recovered to a large extent by a two dimensional model (≈80%) and vice versa (≈90%), and (3) analysis of partial correlations, which emphasized the high correlational nature of valence and tension. Nevertheless, the two possible formulations of the two-dimensional model could not be clearly ranked using these analyses, although the canonical correlations indicated that the version by Russell (1980; valence and arousal) was somewhat more appropriate. Also, the regression approach suggested that the version by Russell was slightly better in accounting ratings of discrete emotions (mean $R^2 = .76$), than the alternative version by Thayer (1989; mean $R^2 = .73$).

These results are in contrast to the ones obtained by proponents of the three-dimensional model (Schimmack & Grob, 2000; Schimmack & Reisenzein, 2002), though we must emphasize the main differences between the design of our study and theirs. Schimmack and Reisenzein

Table 6. Partial correlations between the ratings of basic emotions (N = 110)

	Happiness	Sadness	Tender	Fear
Sadness	–0.88***			
Tenderness	–0.50***	–0.34***		
Fear	–0.84***	–0.73***	–0.63***	
Anger	–0.39***	–0.39***	–0.34***	–0.08

Note: The contribution of all other discrete emotions has been partialled out except the two (row and column) used in the comparison. *** $p < .001$.

(2002) used a questionnaire study with a large number of questions (18) that covered the affect dimensions with several questions (three for each polar extreme). This allowed them to construct and test latent variables from the separately observed variables using structural equation modelling. Also the ratings of their study were based on current mood, and there was no stimulus or manipulation of mood. In our study the ratings were given to emotions that the participants thought the excerpts conveyed, and the excerpts were selected to portray discrete emotions and polar extremes of the dimensional model. Because of this, the observed emotion structure reflects more directly the stimulus structure. It should also be noted that, despite our careful attempts to control the dimensions when selecting excerpts for the experiment based on the results of the pilot experiment, valence and tension were already correlated. Therefore it is difficult to estimate whether it is even possible to separate these dimensions in musical examples. In other words, the question remains as to whether there is an abundant number of musical pieces that could be highly tense and highly positively valenced at the same time. This is therefore something that needs to be studied further.

General discussion

The work presented in this article aimed to systematically compare distinct models of emotion. Although a small number of previous studies exist where discrete and dimensional data have been collected (Gosselin et al., 2006; Kreutz et al., 2008; Vieillard et al., 2008; Zentner et al., 2008), these have been incomplete with regard to the structure of emotion due to their (1) reliance on discrete emotions only, (2) focus on unambiguous exemplars, or (3) insufficient stimulus quantity. Here the set of musical stimuli was carefully selected in a large pilot study to represent emotion concepts in the dimensional as well as the discrete emotion model. Moreover, both models were represented not only by the clearest examples, but also by more moderate examples. This provided subtle nuances for emotion recognition and linear geometry for comparing the two conceptual sets using linear mapping methods.

The comparison of discrete and dimensional models yielded interesting results. Initially we thought that the discrete emotion model would lead to more consistent ratings of emotions than the dimensional model because the terminology (sad, happy, angry, etc.) is already familiar to participants due to their prevalence in the everyday language of the general public. But this was not observed in the data, as the overall consistencies between the ratings in the dimensional and discrete models did not exhibit any substantial differences. However, the discrete emotion model was clearly less reliable in rating excerpts that were ambiguous examples of an emotion category when compared with the dimensional model. This has direct implications for studies that seek to (1) explore mixed emotions (e.g., Hunter et al., 2008), (2) understand the provocative differences in neural processes between dimensional and discrete emotion ratings (e.g., Gosselin et al., 2006), (3) examine processing biases exhibited by clinical populations to inherently ambiguous emotion stimuli (e.g., Bouhuys et al., 1995), or (4) attempt to clarify the way conceptual decisions are made within the framework of the hybrid model of emotions. For such studies, it is important to be aware of this asymmetry in the reliability of the ratings between the two models.

Despite the discrepancy in the resolution between the models, a high correspondence between the discrete and dimensional models was observed. Probably a large part of the assumed differences between the models has been caused by methodological differences. In many of the previous studies on discrete emotions (Dellacherie et al., 2008; Kallinen, 2005; Khalfa et al., 2008b), a forced-choice paradigm is used in emotion recognition. In the present study, all discrete emotions were available in the form of Likert scales, allowing more subtlety in definition than in a forced choice. In this way the methodologies used in both emotion models were similar and thus were perhaps more likely to lead to converging results.

Another way of representing the high correspondence between the two conceptual models is to consider a hybrid model of emotions (Christie & Friedman, 2004; Russell, 2003). This model uses the components of a dimensional model (valence and arousal) to explain the underlying affect space, which is mainly physiologically driven. When the changes in these core affects are interpreted consciously, however, discrete emotion terminology is used to label the emotional experiences. In this way common discrete emotions can be regarded as attractors or hot spots in the affect space. This view is entirely compatible with the results of our experiment – due to the selection of moderately and highly representative examples of discrete emotion categories – and these attractors are explicit in the figures portraying the excerpts along the three dimensions (see Figures 4 and 5). This model could also be used to characterize the main difference between the utilitarian and aesthetic emotions (Scherer, 2004). Whereas the utilitarian emotions such as fear or anger have specific connections to underlying physiology due to the adaptive function they have (in order to protect the physical integrity of the individual), aesthetic emotions do not. Indeed most of the domain-specific emotions established by Zentner et al. (2008) concern positive emotional responses and match the established functions of music as a reminder of past events (North, Hargreaves & Hargreaves, 2004), or have a direct correlate in a core affect (e.g., joyful activation).

The comparison between different versions of the dimensional model indicated that two dimensions are probably sufficient to represent perceived emotions in music. Nevertheless, this should still be studied further as the stimuli in our experiment were initially chosen to represent each of the six dimension extremes separately. Therefore the tense examples in the selection were also the ones which were often negatively valenced. A random sample of a large corpus of music that is known to manipulate emotions could be used to test for the validity of the three-dimensional model in music. Intuitively, the additional dimension of tension makes perfect sense and a great deal of the effects of music deal with patterns of tension and release (Lerdahl, 2001). Moreover, the tension dimension did actually vary independently for certain discrete emotion categories (e.g., sad examples in the lower panel of Figure 5). Tension is also one of the nine factors in the GEMS model of music-induced emotions (Zentner et al., 2008). Whether the other factors in GEMS model actually correspond with the traditionally used terms (sadness, tenderness, peacefulness, and joyful activation to name the obvious ones) is an interesting future research question. Therefore in our opinion, more research as to the specific dimensions required to represent emotions in music is warranted.

In light of the results obtained in this study, we should also investigate more thoroughly the influence of individual factors on the processing of music-mediated emotions, such as personality and musical expertise. It would also be important to evaluate the degree of mismatch between perceived and felt emotions. That would entail changing the rating instruction towards induced emotions but should also incorporate physiological measures, in which significant steps have been recently taken (Baumgartner, Esslen, & Jancke, 2006; Roy, Mailhot, Gosselin, Paquette, & Peretz, 2008; Withvliet & Vrana, 2006). Another important issue is the limitation imposed by the musical style used. Although film music makes use of stereotypical conventions from the romantic era of classical music, as well as more recent ways to use artificial sound schemes and elements from popular music, it has to be acknowledged that the results could well be different with other genres such as pop or jazz. The genre-specificity and stimulus density effects are two related questions that warrant further systematic research in the near future. Also, a thorough dissection of the acoustical and musical features of the stimuli should be carried out in order to address some of the focal issues that have been raised by the study (mixed feelings, the role of timbre, small differences in fear and anger, etc.). Finally, non-verbal methods (such as paired similarity ratings) could give crucial insights into the requisite number of emotion dimensions and categories (Bigand et al., 2005; Vieillard et al., 2008), provided that the initial coverage of the stimuli is reasonably varied (Roberts & Wedell, 2004).

In conclusion, our study demonstrated that discrete and dimensional models of emotion produce highly compatible ratings of perceived emotions, when using a large, systematically chosen set of authentic music from film soundtracks. We also highlighted the noteworthy differences between the models that mostly relate to the constrained resolution of the discrete emotion model. In these respects, our study provides a useful point of reference for exploring the connections between the recognition, experience and physiological manifestations of emotions, as well as the individual variables that moderate all of these.

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Notes

1. https://www.jyu.fi/music/coe/materials/emotion/soundtracks/
2. https://www.jyu.fi/music/coe/materials/emotion/soundtracks/

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Appendix. List of audio tracks used in Experiment

No.	Emotion & level	Album name	Track	Min:Sec
001	Anger high	Lethal Weapon 3	8	04:15–04:29
002	Anger high	The Rainmaker	7	01:45–02:00
003	Anger high	The Alien Trilogy	9	00:03–00:18
004	Anger high	Cape Fear	1	02:15–02:30
005	Anger high	The Fifth Element	19	00:00–00:20
006	Anger mod.	Crouching Tiger, Hidden Dragon	8	01:12–01:25
007	Anger mod.	Batman Returns	2	00:18–00:33
008	Anger mod.	Man of Galilee CD1	6	00:40–01:07
009	Anger mod.	The Untouchables	8	01:38–01:53
010	Anger mod.	Oliver Twist	15	02:05–02:25
011	Fear high	Batman Returns	5	00:09–00:25
012	Fear high	JFK	8	01:26–01:40
013	Fear high	JFK	8	00:08–00:25
014	Fear high	The Alien Trilogy	5	00:26–00:41
015	Fear high	Hannibal	1	00:40–00:54
016	Fear mod.	Running Scared	6	02:53–03:07
017	Fear mod.	The Untouchables	8	01:38–01:53
018	Fear mod.	The Fifth Element	17	00:00–00:19
019	Fear mod.	Lethal Weapon 3	7	00:00–00:16
020	Fear mod.	Man of Galilee CD1	2	03:45–04:02
021	Happy high	The Rainmaker	3	02:55–03:13
022	Happy high	Batman	18	00:55–01:15
023	Happy high	Shallow Grave	6	02:02–02:17
024	Happy high	Man of Galilee CD1	2	03:02–03:18
025	Happy high	Oliver Twist	1	00:17–00:34
026	Happy mod.	The Omen	9	00:00–00:24
027	Happy mod.	Oliver Twist	8	01:40–02:04
028	Happy mod.	Grizzly Man	1	00:00–00:27
029	Happy mod.	The Portrait of a Lady	3	00:23–00:45
030	Happy mod.	Nostradamus	2	01:09–01:28
031	Sad high	The English Patient	18	00:07–00:32
032	Sad high	Running Scared	15	02:06–02:27
033	Sad high	The Portrait of a Lady	9	00:00–00:22
034	Sad high	Big Fish	15	00:55–01:11
035	Sad high	Man of Galilee CD1	8	01:20–01:37
036	Sad mod.	Angel Heart	4	00:08–00:28
037	Sad mod.	Batman	5	01:08–01:22
038	Sad mod.	Dracula	7	00:00–00:12
039	Sad mod.	Shakespeare in Love	3	00:59–01:17
040	Sad mod.	The English Patient	7	00:00–00:31
041	Tender high	Shine	10	01:28–01:48
042	Tender high	Pride & Prejudice	1	00:10–00:26
043	Tender high	Dances with Wolves	4	01:31–01:48
044	Tender high	Pride & Prejudice	12	00:01–00:15
045	Tender high	Oliver Twist	8	00:14–00:30
046	Tender mod.	Batman	9	00:00–00:19
047	Tender mod.	Oliver Twist	8	01:15–01:32
048	Tender mod.	Dracula	4	00:55–01:09
049	Tender mod.	Juha	2	02:11–02:26
050	Tender mod.	Oliver Twist	2	00:00–00:29

(Continued)

Appendix. (Continued)

No.	Emotion & level	Album name	Track	Min:Sec
051	Valence pos. high	Juha	10	00:20–00:38
052	Valence pos. high	Blanc	12	00:51–01:06
053	Valence pos. high	Gladiator	17	00:14–00:27
054	Valence pos. high	Pride & Prejudice	9	00:01–00:21
055	Valence pos. high	Dances with Wolves	10	00:28–00:46
056	Valence pos. mod.	Man of Galilee CD1	2	00:19–00:42
057	Valence pos. mod.	Shakespeare in Love	21	00:03–00:21
058	Valence pos. mod.	Vertigo OST	6	02:02–02:17
059	Valence pos. mod.	Vertigo OST	6	04:42–04:57
060	Valence pos. mod.	Outbreak	6	00:16–00:31
061	Valence neg. mod.	Juha	18	02:30–02:46
062	Valence neg. mod.	Shakespeare in Love	11	00:21–00:36
063	Valence neg. mod.	Batman	9	00:57–01:16
064	Valence neg. mod.	The Fifth Element	9	00:00–00:18
065	Valence neg. mod.	Big Fish	15	00:15–00:30
066	Valence neg. high	The English Patient	8	01:35–01:57
067	Valence neg. high	Lethal Weapon 3	7	00:00–00:16
068	Valence neg. high	Road to Perdition	6	00:34–00:49
069	Valence neg. high	Hellraiser	5	00:00–00:15
070	Valence neg. high	Grizzly Man	16	01:05–01:32
071	Energy pos. high	The Untouchables	6	01:50–02:05
072	Energy pos. high	Man of Galilee CD1	2	03:02–03:18
073	Energy pos. high	Shine	5	02:00–02:16
074	Energy pos. high	Shine	15	01:00–01:19
075	Energy pos. high	Batman	18	00:55–01:15
076	Energy pos. mod.	Juha	2	00:07–00:18
077	Energy pos. mod.	Lethal Weapon 3	4	01:40–02:00
078	Energy pos. mod.	Crouching Tiger, Hidden Dragon	13	01:52–02:10
079	Energy pos. mod.	Batman	4	02:31–02:51
080	Energy pos. mod.	Oliver Twist	7	01:30–01:46
081	Energy neg. mod.	Juha	16	00:00–00:15
082	Energy neg. mod.	Big Fish	15	00:55–01:11
083	Energy neg. mod.	Big Fish	11	01:26–01:40
084	Energy neg. mod.	Blanc	18	00:00–00:16
085	Energy neg. mod.	Oliver Twist	6	00:51–01:07
086	Energy neg. high	Running Scared	15	02:06–02:27
087	Energy neg. high	Road to Perdition	16	00:17–00:32
088	Energy neg. high	Blanc	10	00:13–00:31
089	Energy neg. high	Blanc	16	00:00–00:15
090	Energy neg. high	Batman Returns	12	00:57–01:14
091	Tension pos. high	The Alien Trilogy	11	02:12–02:27
092	Tension pos. high	The Fifth Element	13	00:17–00:31
093	Tension pos. high	Babylon 5	3	02:47–03:00
094	Tension pos. high	Hellraiser	10	02:44–03:00
095	Tension pos. high	Oliver Twist	15	02:05–02:25
096	Tension pos. mod.	The Missing	3	02:45–03:06
097	Tension pos. mod.	Shallow Grave	4	01:04–01:19
098	Tension pos. mod.	Naked Lunch	7	01:01–01:20
099	Tension pos. mod.	Dracula	5	00:11–00:27
100	Tension pos. mod.	Cape Fear	2	01:25–01:40

(Continued)

Appendix. (Continued)

No.	Emotion & level	Album name	Track	Min:Sec
101	Tension neg. mod.	Juha	2	02:11–02:26
102	Tension neg. mod.	Shakespeare in Love	6	00:00–00:19
103	Tension neg. mod.	The Fifth Element	12	00:00–00:17
104	Tension neg. mod.	Crouching Tiger, Hidden Dragon	11	00:28–00:46
105	Tension neg. mod.	Pride & Prejudice	4	00:10–00:29
106	Tension neg. high	Lethal Weapon 3	10	01:59–02:17
107	Tension neg. high	The Godfather	5	01:12–01:28
108	Tension neg. high	Gladiator	4	00:48–01:06
109	Tension neg. high	Pride & Prejudice	13	01:02–01:20
110	Tension neg. high	Big Fish	8	00:12–00:34

II

THE ROLE OF MOOD AND PERSONALITY IN THE PERCEPTION OF EMOTIONS REPRESENTED BY MUSIC

by

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The role of mood and personality in the perception of emotions represented by music

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ABSTRACT

Neuroimaging studies investigating the processing of emotions have traditionally considered variance between subjects as statistical noise. However, according to behavioural studies, individual differences in emotional processing appear to be an inherent part of the process itself. Temporary mood states as well as stable personality traits have been shown to influence the processing of emotions, causing trait- and mood-congruent biases. The primary aim of this study was to explore how listeners' personality and mood are reflected in their evaluations of discrete emotions represented by music. A related aim was to investigate the role of personality in music preferences. An experiment was carried out where 67 participants evaluated 50 music excerpts in terms of perceived emotions (anger, fear, happiness, sadness, and tenderness) and preference. Current mood was associated with mood-congruent biases in the evaluation of emotions represented by music, but extraversion moderated the degree of mood-congruence. Personality traits were strongly connected with preference ratings, and the correlations reflected the trait-congruent patterns obtained in prior studies investigating self-referential emotional processing. Implications for future behavioural and neuroimaging studies on music and emotions are raised.

1. Introduction

Neuroimaging studies investigating the processing of emotions have traditionally relied on group-averaged brain activations, and considered variance between subjects as statistical noise (for a review, see Plomin and Kosslyn, 2001). However, according to behavioural studies, individual differences in emotional processing appear to be an inherent part of the process itself (for a review, see Rusting, 1998), and these differences may be essential in unravelling the neural circuits involved in the processing of emotions (Hamann and Canli, 2004). Behavioural studies have associated both temporary mood states as well as stable personality traits with individual differences in emotional processing, but it is still not clearly understood what the mechanisms behind these individual differences are (Rusting, 1998).

Extraverts have been shown to be particularly susceptible to positive affect, and neurotics to negative affect. Matthews et al. (1990) found that extraverts tend to experience more pleasant moods, whereas high neuroticism scorers tend to experience more unpleasant moods. Similarly, Rusting and Larsen (1997), and Larsen and Ketelaar (1991) reported that extraversion

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correlated with positive mood after positive mood manipulation (but not with negative mood after negative mood manipulation), while neuroticism correlated with negative mood after negative mood manipulation (but not with positive mood after positive mood manipulation). These findings are in line with personality theory, according to which one of the definitions of extraversion is the tendency to experience positive emotions, while neuroticism is defined as the tendency to experience negative emotions such as depression, anger, and anxiety (see e.g., John and Srivastava, 1999).

Extraversion and neuroticism have also been connected with individual differences in brain function: Neuroticism has been associated with heightened brain activity (at rest and in response to negative stimuli) in brain regions associated with negative affect, whereas extraversion has been associated with brain activity (at rest and in response to positive stimuli) in brain regions that are important for reward and approach behaviour (for a review, see DeYoung and Gray, 2009). More specifically, Canli et al. (2002) discovered that extraversion correlated with amygdala activation to happy faces. However, when they used group-averaged data, they only found significant amygdala activation to fearful faces – a finding consistent with previous research.

Both personality and mood have been associated with affect-congruent biases in emotional judgments, but their role might depend on the type of emotional processing in question (for a review, see Rusting, 1998). A study by Martin et al. (1983) demonstrated that high neuroticism scorers recalled more negative information about themselves (but not about others), and this effect was not related to depressed mood. More recently, Zelenski and Larsen (2002) found that extraversion and neuroticism biased participant's self-referential judgments in trait-congruent directions, and these personality effects were also not mediated by mood states. The key aspect of self-reference is that the self acts as a setting against which incoming data are interpreted (see e.g., Rogers et al., 1977). Extraversion predicted increased likelihood judgments for positive future events, while neuroticism predicted increased likelihood judgments for negative events.

Mood states have been reported to cause affect-congruent biases especially in tasks involving more cognitive judgments. Bouhuys et al. (1995) discovered that induced depressed mood influenced the perception of facial emotional expressions in healthy participants. When feeling more depressed, the participants perceived more sadness/rejection in ambiguous faces, and less happiness/invitation in clear faces. Similarly, Isen and Shalker (1982) found that induced negative mood led to lower pleasantness ratings for pleasant, ambiguous, and unpleasant slides, while induced positive mood led to higher pleasantness ratings.

According to Rusting (1998), positive emotional traits such as extraversion may alter the processing of emotional cues in the presence of a negative mood state. Because extraversion represents the tendency to avoid negative stimuli (and to focus on positive stimuli) when experiencing negative mood states, it should also moderate the extent to which mood-congruency effects emerge. In contrast, individuals scoring high in neuroticism should be especially susceptible to negative mood-congruent thoughts. Richards et al. (1992) reported that the effect of induced state anxiety on performance on the emotional Stroop task was modulated by the participants' trait anxiety. Participants with high trait anxiety had an attentional bias towards stimuli which were congruent with their (induced) mood, while participants scoring low in trait anxiety had a tendency in the opposite direction. Similarly, a study by Rusting (1999) demonstrated that positive mood-congruence was stronger for participants scoring high in positive affectivity, while neuroticism and negative affectivity moderated the mood-congruence effect for negative emotions. However, the moderating effect of personality was only observed when mood was manipulated.

The last decade has seen the emergence of functional neuroimaging studies investigating the neural substrates of emotions using musical stimuli (for a review, see Koelsch et al., 2010). One issue that has held back advances in identifying the neural circuits involved in the processing of different emotions is the difficulty of eliciting strong and differentiated emotional responses in a laboratory environment (Barrett and Wager, 2006). However, music as a stimulus holds a lot of potential for future research: Music is capable of expressing and inducing fairly intense emotions – both positive and negative (see e.g., Zentner et al., 2008) – and music also enables the investigation of both affective and aesthetic appraisals simultaneously (for a review, see Brattico and Jacobsen, 2009; Nieminen et al., 2011, this issue).

In order to elucidate the neural basis of emotional processing, future neuroimaging studies on music and emotions should move beyond group-averaged brain activations, and include individual difference measures (e.g., personality) in the analyses. However, before this can be attempted, behavioural investigations on the role of individual differences in the perception of musical emotions as well as in music preferences (with regard to the emotion expressed) should provide evidence regarding the traits and states that might be involved. Personality traits have previously been associated with emotions induced by music (Kreutz et al., 2008) as well as with preferences for different musical genres (Rawlings and Ciancarelli, 1997; Rentfrow and Gosling, 2003), but their role in the perception of musical emotions has remained unclear. In addition, the affective aspects of music preferences – the role of emotions expressed by music – have also received little attention in previous studies (for a review, see Rentfrow and McDonald, 2010). Since preference is subjective by definition, it could be speculated that preference for music expressing different emotions (e.g., sadness or happiness) might reflect the pattern of trait-congruent biases found in self-referential emotional processing (e.g., Martin et al., 1983; Zelenski and Larsen, 2002).

Thus, the primary aim of this study was to investigate how listeners' personality traits and current mood are associated with their evaluations of discrete emotions represented by music. Based on the previous literature, it was hypothesized that both personality and mood would contribute to the perception of emotions in trait- and mood-congruent manners, and that mood and personality would also interact in producing affect-congruent biases. The possible interaction of mood and personality has received little attention in studies investigating trait- and mood-congruence (for a review, see Rusting, 1998), although some evidence of such interactions exists (see e.g., Rusting, 1999).

A related aim was to investigate the role on personality and mood in music preferences (with regard to the emotion expressed by the music), as preference ratings for music excerpts might provide a novel way of investigating self-referential emotional processing. Music preferences and their relation to individual differences are also of significance for neuroimaging studies on music and emotions, since aesthetic and subjective appreciation are some of the most common experiences associated with music listening (see e.g., Brattico and Jacobsen, 2009; see also Nieminen et al., 2011, this issue). It was hypothesized that music preferences and personality traits would exhibit a pattern of affect-congruent biases similar to the ones reported in studies investigating self-referential emotional processing (e.g., Martin et al., 1983; Zelenski and Larsen, 2002).

2. Methods

2.1. *Participants*

67 Finnish university students aged 18–42 years (mean 25.2, standard deviation 3.93, 66% females) took part in the experiment. Although a portion of the participants had received musical training or had music as a hobby, they were not selected according to any musical skills or musical background. The participants received movie tickets in return for their participation.

2.2. *Measures*

Before the actual listening experiment, the participants' personality traits were assessed using "The Big Five Inventory" (BFI; John and Srivastava, 1999). The BFI has 44 items that measure five broad personality domains labeled Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness to experience. The items were rated on a 5-point Likert scale (1 = disagree strongly, 5 = agree strongly). In addition, their current mood prior to taking the test was evaluated using the Profile of Mood States-Adolescents questionnaire (Terry et al., 1999; see Terry et al., 2003 for validation for adult populations), which measures 6 factors of mood (Vigour, Confusion, Anger, Fatigue, Depression, and Tension). Although it is possible that the experiment itself might have had a slight effect on the participants' mood, it is unlikely that this effect was systematically caused by the music excerpts, since the excerpts were short (15 sec; a total duration of <13 min), and the emotions represented by them varied considerably in valence and arousal. Furthermore, any possible boredom or fatigue effects would have been reduced to random noise due to the randomization of individual excerpt orders. After the experiment, a short questionnaire was given out to gather information about the participants' film genre preferences, musical training, and any possible hearing problems.

2.3. *Stimuli*

The stimulus material consisted of 50 film music excerpts representing anger, fear, happiness, sadness and tenderness (for the list of excerpts, see appendix in Eerola and Vuoskoski, 2011; excerpts 001–050). Film music was used because it is composed for the purpose of mediating powerful emotional cues, and it could serve as an ecologically valid and diverse stimulus material. Each excerpt was 15 sec long, and there were both highly and moderately typical examples of each discrete emotion ([5 high + 5 moderate examples] × 5 emotions). The excerpts were selected on the basis of a pilot experiment from a set of 360 film music excerpts collected by a panel of musicologists (for details, see Eerola and Vuoskoski, 2011).

2.4. *Procedure*

The participants were instructed to rate the emotions that the music was expressing in their opinion (i.e., perceived emotions), and the difference between perceived and felt emotions was explained to them. The emotion ratings were collected using 5 discrete emotion scales (anger, fear, happiness, sadness and tenderness), ranging from 1 to 9 (1 = not at all angry, 9 = very angry, etc.). These five emotions have been documented to be commonly expressed and induced by music, and are easily recognized by listeners (see e.g., Juslin and Laukka, 2004). The participants were instructed to use as many scales as they found appropriate for each excerpt. The participants also rated how much they liked each excerpt (1 = I do not like at all, 9 = I like very much).

2.5. *Apparatus*

The listening experiments were conducted individually for each participant in a soundproof room. Participants listened to the excerpts through studio quality headphones (AKG K141 Studio), and rated the excerpts using a computer interface that enabled them to move from one excerpt to the next at their own pace. The stimuli were presented in a different random order for each participant.

3. Results

3.1. *Correlations between personality traits, mood states, and emotion ratings*

Overall, the emotion ratings were highly consistent (Cronbach alphas for all emotion scales were above .99). Such high alphas are not uncommon when measuring perceived emotions in music (see e.g., Eerola and Vuoskoski, 2011), and even studies investigating musically induced emotions (which are known to be more subjective) have reported alphas close to 1 (see e.g., Zentner et al., 2008). To eliminate the effect of possible individual differences in scale use, the raw emotion ratings were standardized within subjects using individual z-score transforms (with the exception of liking ratings). The z-scores were calculated using all emotion ratings of each participant. Table 1 shows the correlations between personality traits and the mean emotion ratings of each participant. The mean emotion ratings were calculated using ratings given for all 50 excerpts (i.e., the mean sadness rating of a participant was calculated from that participant's sadness ratings for all 50 excerpts). This enabled the investigation of overall biases in scale use, as has been done in previous studies (see e.g., Isen

Table 1 – Correlations between personality traits and mean emotion ratings.

	Anger	Fear	Happiness	Sadness	Tenderness
Extraversion	.20	−.06	.12	−.27*	.03
Agreeableness	.21	−.01	−.02	−.22	.06
Conscientiousness	.02	−.15	−.11	.09	.12
Neuroticism	−.08	.03	−.21	.25*	−.01
Openness	.24	−.14	−.12	−.14	.15

*$p < .05$.

and Shalker, 1982; Bouhuys et al., 1995). Levene's test was used to assess the equality of variances in the mean emotion ratings, and it confirmed the homogeneity of the variances in all 5 emotion scales ($p = .677$). Only two statistically significant correlations emerged; neuroticism correlated positively with sadness ratings ($r = .25$, $p < .05$), while extraversion and sadness ratings had a negative correlation ($r = -.27$, $p < .05$). These results are in line to a certain extent with the hypothesis concerning trait-congruency, according to which extraversion is related to the perception of positive emotional cues, and neuroticism to the perception of negative emotional cues (see e.g., Rusting, 1998). As we used mean sadness ratings (calculated from the sadness ratings for all 50 excerpts) in the analysis, it also takes into consideration the sadness ratings given for tender and fearful (etc.) excerpts. Thus, the negative correlation between extraversion and sadness ratings reflects a general scale-use bias towards positive emotions, as positive and negative affect (and happiness and sadness) can be seen as the opposite extremes of a bipolar continuum (see e.g., Russell, 1980). However, the correlations between personality traits and happiness ratings were not statistically significant (extraversion, $r = .12$, $p =$ n.s.; neuroticism, $r = -.21$, $p =$ n.s.), although the trend was towards trait-congruency.

The correlations between mood states and mean emotion ratings are shown in Table 2. The overall magnitude of the correlations between mood states and emotion ratings was higher than in the case of personality traits and emotion ratings, and there were several statistically significant correlations. For example, vigour correlated positively with happiness ratings ($r = .32$, $p < .01$), anger correlated negatively with happiness ratings ($r = -.38$, $p < .01$), and depression and sadness ratings had a positive correlation ($r = .40$, $p < .001$). These mood-congruent correlations are consistent with results obtained in studies utilizing mood manipulation (e.g., Bouhuys et al., 1995; Isen and Shalker, 1982), and imply a strong connection between mood and emotional evaluations.

According to personality theory as well as the results of previous studies (e.g., Rusting and Larsen, 1997; Larsen and Ketelaar, 1991; Matthews et al. 1990), certain personality traits are thought to predispose to certain mood states. Since both personality traits and current mood seem to be related to the emotional evaluation of music excerpts, the correlations between extraversion, neuroticism, and current mood (shown in Table 3) should also be investigated. As expected, there were several statistically significant correlations in trait-congruent directions. For example, neuroticism correlated positively with depression ($r = .31$, $p < .05$), tension ($r = .37$, $p < .01$), and confusion ($r = .39$, $p < .001$), while extraversion had a negative correlation with tension ($r = -.37$, $p < .01$). In addition, extraversion and neuroticism also had a strong, negative correlation ($r = -.58$, $p < .001$).

According to Rusting (1998), emotional processing is most likely influenced by both mood and personality, since personality traits represent underlying propensities towards mood states (but do not necessarily always produce them). However, it is still unclear how mood and personality traits interact in the process. Therefore, we decided to proceed by examining partial correlations between personality and emotion ratings while controlling for mood, as well as partial correlations between current mood and emotion ratings while controlling for personality. When current mood was controlled for, the previously significant correlations between personality traits (extraversion and neuroticism) and sadness ratings became statistically non-significant (sadness and neuroticism: $r = .14$, $p =$ n.s.; sadness and extraversion: $r = -.19$, $p =$ n.s.). However, when personality traits were controlled for, most of the correlations between mood and emotion ratings remained statistically significant (see Table 4). Although these results imply that the role of mood in emotional evaluations might be greater than the role of personality, a more detailed analysis of the independent and

Table 2 – Correlations between mood states and mean emotion ratings.

	Anger	Fear	Happiness	Sadness	Tenderness
Vigour	−.09	.14	.32**	−.23	−.11
Confusion	−.07	−.03	−.20	.21	.08
Anger	.03	−.11	−.38**	.33**	.11
Fatigue	.24*	−.12	−.32**	.14	.04
Depression	−.11	−.10	−.28*	.40***	.04
Tension	−.09	−.13	−.09	.26*	.00

*$p < .05$, **$p < .01$, ***$p < .001$.

Table 3 – Correlations between mood states and the personality traits extraversion and neuroticism.

	Neuroticism	Extraversion
Vigour	−.26*	.13
Confusion	.39***	−.22
Anger	.28*	−.21
Fatigue	.20	−.04
Depression	.31*	−.22
Tension	.37**	−.37**
Neuroticism		−.58***

*$p < .05$, **$p < .01$, ***$p < .001$.

Table 4 – Partial correlations between current mood and mean emotion ratings, when personality traits are controlled for.

	Anger	Fear	Happiness	Sadness	Tenderness
Vigour	−.11	.13	.24	−.15	−.08
Confusion	−.05	−.06	−.13	.14	.10
Anger	.05	−.09	−.33**	.27*	.08
Fatigue	.25*	−.10	−.26*	.09	.01
Depression	−.10	−.12	−.20	.35**	.04
Tension	.01	−.19	−.07	.17	.04

*$p < .05$, **$p < .01$.

interaction effects of the two variables is necessary and presented next.

3.2. *Moderated multiple regression (MMR) analysis*

MMR is an analysis method that allows investigating whether the effect of an independent variable on the dependent variable is moderated by a moderator variable. In other words, it allows testing for interactions between variables by entering two predictor variables and the product of those variables (i.e., interaction) into a linear regression equation (Aiken and West, 1991). The results of the correlation analyses as well as the results of previous studies contributed to the formulation of several regression models, which were tested using MMR. Three of the regression models were statistically significant: Extraversion and depression had a significant interaction effect in explaining the inter-subject variance in the participants' mean sadness ratings, and extraversion and vigour as well as extraversion and fatigue had a significant interaction effect in explaining happiness ratings (regression summary in Table 5).

As can be seen from Table 5, extraversion in itself was not a significant predictor in any of the regression models. Only the different mood states and the interaction between extraversion and mood were significant predictors of the inter-subject variance in the participants' emotion ratings, which further suggest that extraversion moderated the degree of mood-congruence, and not vice-versa. The moderating effects of extraversion on the relationships between mood and emotion ratings are visualized in Fig. 1. For example, the upper panel in Fig. 1 shows how the correlation between vigour and happiness ratings increases when extraversion increases (participants have been divided in three groups according to extraversion scores). The middle panel displays a similar trend for fatigue and happiness ratings (the degree on mood-congruence increases when extraversion increases), and the lowest panel demonstrates the relationship between depression and sadness ratings. Based on the results of the moderated regression analysis, we can infer that the degree of mood-congruence in the emotion ratings is at least to some extent moderated by personality traits.

3.3. *Personality, mood, and music preferences*

Finally, we examined whether personality traits and mood states correlate with preference ratings for excerpts expressing each discrete emotion. Since aesthetic and subjective appreciation are some of the most common experiences associated with music listening (see e.g., Brattico and Jacobsen, 2009; Nieminen et al., 2011, this issue), the affective aspects of music preferences may offer a novel way of investigating self-referential emotional processing. For each participant, we calculated a mean preference rating for the 10 excerpts expressing each of the 5 discrete emotions. These mean preference ratings were then correlated with the personality- and mood variables. As expected, current mood and preference ratings did not appear to be strongly connected, as there were only two statistically significant correlations: tension correlated negatively with liking for happy-sounding music ($r = -.29$, $p < .05$) and with liking for tender-sounding music ($r = -.26$, $p < .05$). In Table 6, the correlations between personality traits and mean liking ratings for excerpts representing each discrete emotion are displayed. Liking for happy-sounding music correlated strongly with agreeableness ($r = .47$, $p < .001$) and extraversion ($r = .32$, $p < .01$), while openness to experience correlated positively with liking for fearful-sounding ($r = .26$, $p < .05$) and sad-sounding music ($r = .32$, $p < .01$). Agreeableness also had a negative correlation with liking for angry-sounding ($r = -.29$, $p < .05$) and fearful-sounding music ($r = -.36$, $p < .01$). The correlations between liking and personality seem to be mostly trait-congruent, although the correlations between openness to experience and liking for fearful- and sad-sounding music could result from openness towards different kinds of music.

Compared to neuroticism and extraversion, there is less evidence regarding the biological substrates of agreeableness, openness to experience, and conscientiousness, and their role in emotional processing (for reviews, see DeYoung and Gray, 2009; Rusting, 1998). However, agreeableness has been defined as a prosocial orientation towards others (altruism,

Table 5 – MMR summary (DV = dependent variable, IV = independent variable, M = moderator variable, I = interaction of IV and M).

DV	IV: Depression M: Extraversion R^{2adj} (β)	IV: Fatigue M: Extraversion R^{2adj} (β)	IV: Vigour M: Extraversion R^{2adj} (β)
Sadness ratings	.21*** ($IV_{.29}$*, $M_{-.18}$, $I_{-.21}$*)		
Happiness ratings		.19*** ($IV_{-.43}$***, $M_{.17}$, $I_{-.32}$**)	.12** ($IV_{.32}$**, $M_{.13}$, $I_{.23}$*)

β = Standardized beta coefficients. Asterisks denote the significance level of F as well as the significance of the explanatory variables (*$p < .05$, **$p < .01$, *** $p < .001$).

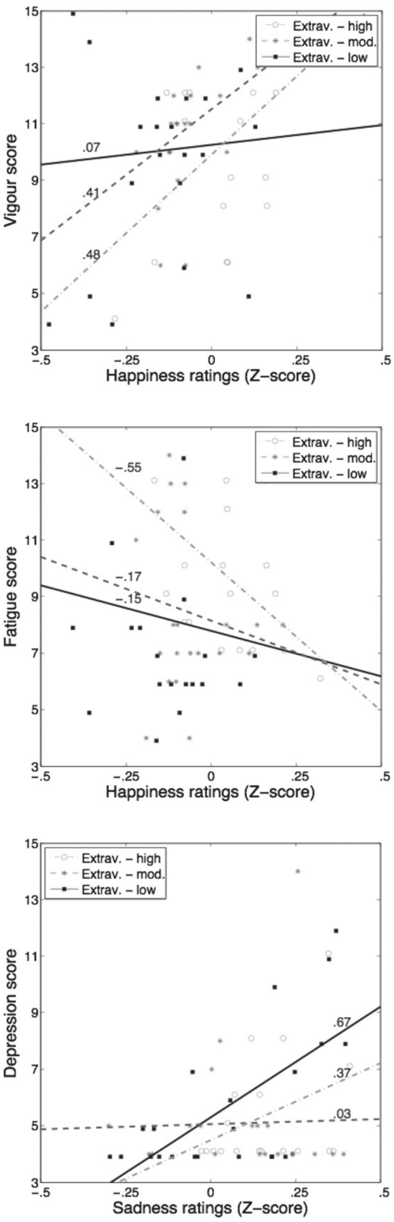

Fig. 1 – The correlations between mood states (vigour, fatigue, and depression) and emotion ratings vary depending on the level of extraversion (highest third, middle third, and lowest third).

tender-mindedness, trust, and modesty; see e.g., John and Srivastava, 1999), which is in line with the positive correlations between agreeableness and liking for happy- and tender-sounding music, as well as the negative correlations between agreeableness and liking for angry- and fearful-sounding music. Trait-congruent trends were also visible for neuroticism (e.g., neuroticism and liking for happy-sounding music; $r = -.23$, $p = \text{n.s.}$), but these correlations failed to reach statistical significance.

4. Discussion

The results of the present study suggest that both mood and personality are involved in the perception of emotions represented by music, but their relationship appears to be rather complex. Although personality traits predispose to certain mood states (e.g., Matthews et al., 1990; Rusting, 1998), they also seem to moderate the degree of mood-congruence in the emotion ratings. In the present study, extraversion moderated the relationship between depression and sadness ratings, as well as the relationships between vigour and happiness ratings, and fatigue and happiness ratings. These results are partly in line with the findings of Rusting (1999), who discovered that neuroticism and negative affectivity moderated negative mood-congruence, and positive affectivity moderated positive mood-congruence. However, in contrast with the results of the present study, the interaction of personality and mood was only present when mood had been manipulated.

It should be noted that the moderated regression models only accounted for a relatively small part of the inter-subject variance in the participants' mean emotion ratings ($R^{2adj} = .12–.21$), and this raises further questions about other variables that might influence individual differences in emotion perception. Interestingly, Tomarken et al. (1990) found that affect ratings for films were better predicted by baseline frontal asymmetry (measured using electroencephalography) than by current mood – even when mood was accounted for. This finding could provide an interesting direction for further work, and highlights the potential advances that could be made by utilizing neuroimaging methods in the investigation of individual differences in emotional processing. Regarding the variance that can be attributed to the musical content of the excerpts, it should be noted that the mean emotion ratings given to each excerpt can be explained to a large degree (45–75%) by the acoustical and musical features of the stimuli (according to an analysis based on the data used in the present study; see Eerola et al., 2009; for a similar account, see also Schubert, 2004).

Personality traits were strongly associated with preference ratings for music excerpts expressing different emotions. As hypothesized, the correlations mostly reflected the trait-congruent patterns obtained in previous studies investigating self-referential emotional processing (e.g., Martin et al., 1983; Zelenski and Larsen, 2002), although the results regarding neuroticism did not reach statistical significance. Agreeableness was strongly associated with liking for happy- and tender-sounding music, and with disliking for angry- and fearful-sounding music, which is in line with the definition of agreeableness as a prosocial trait. Future studies on emotional

Table 6 – Correlations between personality traits and mean preference ratings for excerpts representing each discrete emotion.

	Preference (liking) for excerpts representing the emotion in question				
	Anger	Fear	Happiness	Sadness	Tenderness
Extraversion	−.06	−.16	.32**	.08	.17
Agreeableness	−.29*	−.36**	.47***	.05	.25*
Conscientiousness	−.13	−.03	.02	.13	.21
Neuroticism	.09	.13	−.23	.07	−.14
Openness	.16	.26*	−.04	.32**	.06

*$p < .05$, **$p < .01$, ***$p < .001$.

processing should also investigate other traits than just extraversion and neuroticism, as they may also contribute to response biases. The findings of the present study offer intriguing possibilities for future research, since music appears to enable the investigation of both cognitive and self-referential emotional processing simultaneously. In the present experiment both types of ratings (emotion ratings and preference ratings) were collected simultaneously, but they still exhibit clearly different trait- and mood-congruent patterns. This may also present new challenges for neuroimaging studies on music and emotions, since these two types of processing might have differing neural circuits.

Although the results should be considered only suggestive due to the small sample size and the non-causal experimental paradigm, they raise interesting questions that are amenable to direct empirical experiments. For example, mood manipulation could be used to decompose the interrelations between mood and personality, and to clarify the different roles of personality in cognitive and self-referential evaluations. Moreover, the properties of the stimuli that evoke mood- and personality-related differences could also be explored in more detail. For example, ambiguous stimuli may add to judgement biases related to personality or mood (e.g., Bouhuys et al., 1995).

The results of the present study have implications not only for the field of music and emotions, but also for emotion research in general, as they demonstrate that personality traits may moderate the degree of mood-congruence in cognitive emotional processing even when mood is not manipulated (c.f., Rusting, 1999). Musical stimuli provide a realistic and effective way of exploring the interaction of mood and personality in emotional processing, and they also allow exploring the more self-referential aspects of emotions simultaneously. In summary, this study demonstrated that personality and mood do play an important role in the processing of musical emotions, and that music preferences and personality traits exhibit strong, trait-congruent connections. Perhaps these findings will provide motivation for future neuroimaging studies on music and emotions to move beyond group-averaged brain activations, and hopefully shed more light on the complex phenomenon of individual differences in emotional processing.

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III

MEASURING MUSIC-INDUCED EMOTION: A COMPARISON OF EMOTION MODELS, PERSONALITY BIASES, AND INTENSITY OF EXPERIENCES

by

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Measuring music-induced emotion: A comparison of emotion models, personality biases, and intensity of experiences

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Abstract
Most previous studies investigating music-induced emotions have applied emotion models developed in other fields to the domain of music. The aim of this study was to compare the applicability of music-specific and general emotion models – namely the Geneva Emotional Music Scale (GEMS), and the discrete and dimensional emotion models – in the assessment of music-induced emotions. A related aim was to explore the role of individual difference variables (such as personality and mood) in music-induced emotions, and to discover whether some emotion models reflect these individual differences more strongly than others. One hundred and forty-eight participants listened to 16 film music excerpts and rated the emotional responses evoked by the music excerpts. Intraclass correlations and Cronbach alphas revealed that the overall consistency of ratings was the highest in the case of the dimensional model. The dimensional model also outperformed the other two models in the discrimination of music excerpts, and principal component analysis revealed that 89.9% of the variance in the mean ratings of all the scales (in all three models) was accounted for by two principal components that could be labelled as valence and arousal. Personality-related differences were the most pronounced in the case of the discrete emotion model. Personality, mood, and the emotion model used were also associated with the intensity of experienced emotions. Implications for future music and emotion studies are raised concerning the selection of an appropriate emotion model when measuring music-induced emotions.

Keywords
emotion models, individual differences, music-induced emotions

Introduction

Music-induced emotions are an inseparable part of music listening, as most listeners claim to experience strong emotions in response to music at least half of the time they spend listening to it (Juslin & Laukka, 2004). Although the focus of music and emotion studies has been quite equally divided between perceived and felt emotions over the past 20 years (Eerola & Vuoskoski,

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submitted), there is continuing controversy over what kind of emotions music can actually induce in the listener (see, e.g., Juslin & Västfjäll, 2008; Konečni, 2008; Scherer, 2004). Despite this controversy, most previous studies investigating music-induced emotions have applied emotion models developed in fields other than the domain of music. A recent review of music and emotion studies (Eerola & Vuoskoski, submitted) revealed that the two most commonly used emotion models have been the discrete emotion model (i.e., basic emotions such as happiness, sadness, fear, and anger) and the two-dimensional circumplex model (comprising the orthogonal dimensions of valence and arousal; Russell, 1980). The discrete emotion model has often been modified to better describe emotions that are commonly represented by music, by replacing emotions such as disgust or surprise with more suitable emotion concepts such as tenderness or peacefulness (see, e.g., Gabrielsson & Lindström, 1995; Vieillard, Peretz, Gosselin, Khalfa, Gagnon, & Bouchard, 2008). However, it is still unclear whether models and theories designed for 'everyday' emotions can also be applied to an aesthetic context such as music, and there have been doubts whether a few primary basic emotions – or the two dimensions of valence and arousal – are adequate to describe the richness of emotional experiences induced by music (Zentner, Grandjean, & Scherer, 2008).

In 2008, Zentner, Grandjean, and Scherer published a pioneering study in which they introduced a new domain-specific emotion model for the measurement of music-induced emotions: the Geneva Emotional Music Scale (GEMS). They also provided a comparison between the GEMS and the two most commonly used emotion models, the basic emotion model (i.e., discrete emotions) and the two-dimensional circumplex model. However, as they only used western classical music in the comparison, and their formulation of the basic emotion model was somewhat unconventional (in the context of music and emotions), their conclusions about the superiority of the GEMS require further study.

In their comparison study, Zentner et al. (2008) used a version of the basic emotion model that included emotions such as shame, guilt, disgust, and contempt – emotions that are very rarely expressed or induced by music (see, e.g., Juslin & Laukka, 2004) or used in other studies investigating music and emotions (Eerola & Vuoskoski, submitted). The two-dimensional circumplex model was represented in the form of eight adjective groups, which were taken from the extremes of the two dimensions as well as from the quadrants between them, thus covering the entire affective space. However, the stimuli used by Zentner et al. (2008) did not represent the affective space in a comprehensive or balanced manner, as the stimuli were selected based on their potential effectiveness in inducing anger, fear, happiness, sadness, and "some of the novel emotion categories" (p. 508) included in the GEMS. In addition, the novel stimuli (i.e., the stimuli not used in previous experiments) used by Zentner et al. (2008) were not validated in terms of the emotions represented by them. We speculate that the reason for the use of the aforementioned emotion model formulations was to have a similar number of scales in the three models. In the present study, however, we wanted to replicate the comparison done by Zentner et al. (2008) while doing equal justice to all three models by using more conventional and simpler formulations (i.e., formulations that have previously been employed in studies of music and emotions) of the discrete and dimensional models, and by using ecologically valid and emotionally diverse stimulus material.

In the present experiment we used Finnish translations of the 26 adjectives representing the nine rating scales of GEMS-9 (Zentner et al., 2008). As Zentner and et al. originally conducted their series of studies in French, there are potential language issues related to the published version of GEMS (which is an English translation of the original). Since the present Finnish translation is based on the English version, it is possible that some nuances of the original GEMS may have been lost in translation. In our formulation of the discrete emotion model we included the emotions *happiness, sadness, anger, fear,* and *tenderness*, which are commonly expressed (and also induced) by music, and easily recognized by listeners (see, e.g., Juslin & Laukka, 2004). As for the formulation of the dimensional emotion model, we decided to use the three-dimensional emotion model (Schimmack & Grob, 2000), which comprises the dimensions of *valence* (pleasant–unpleasant), *energy* (awake–tired), and *tension* (tense–relaxed). Each dimension was represented by two unipolar scales. The three-dimensional model has previously been used in the measurement of perceived emotions in music, where it has provided highly consistent and reliable ratings (Eerola & Vuoskoski, 2011; Ilie & Thompson, 2006). These selections resulted in the three models having a differing number of scales, which has to be taken into consideration in the comparison and interpretation of the results. However, the differing number of scales will also allow us to explore the issue of scale redundancy in relation to discriminative power. In other words, although models with more scales are able to give more detailed and nuanced information, they might not be the most economical self-report instruments for felt emotions.

The consistency of ratings (i.e., agreement among people) is often used as a measure of how well an instrument performs, and it was also one of the measures used by Zentner et al. (2008) in their comparison of the three emotion models. However, in emotional processing, individual differences seem to be the rule rather than the exception (for a review, see Rusting, 1998). Both temporary mood states and stable personality traits have been associated with individual differences in emotional processing: extraverted people and people in positive moods have been shown to be particularly susceptible to positive affect, and neurotic people (and people in negative moods) to negative affect (for a review, see Rusting, 1998). Personality traits and mood states have also been associated with trait- and mood-congruent biases in emotional judgments in general (Rusting, 1998), as well as in the perception of emotions represented by music (Vuoskoski & Eerola, in press). Furthermore, certain personality traits (e.g., absorption and behavioural inhibition/activation) have been shown to play a role in emotional responses to music (Kallinen & Ravaja, 2006; Kreutz, Ott, Teichmann, Osawa, & Vaitl, 2008), and empathy and emotional contagion have been mentioned as possible mechanisms through which music can induce emotions (Juslin & Västfjäll, 2008; Scherer & Zentner, 2001).

Taking the individual differences between listeners into account can enable a more comprehensive picture of the emotional responses induced by music to emerge. Interestingly, Barrett (1998, 2006) has discovered that people with different personalities differ in emotional granularity (i.e., the level of detail people use to describe emotions experienced in everyday contexts). More specifically, people tend to vary in the extent to which they focus on the valence and arousal of their emotional experiences. "Valence focus" is related to valuation sensitivity (i.e., the sensitivity to reward and punishment cues), which is an integral part of the personality traits of extraversion and neuroticism (Barrett, 2006). Individuals high in valence focus tend to emphasize the hedonic contents of their experience, and use different negative (or positive) emotion words interchangeably to describe the same unpleasant (or pleasant) experience. In contrast, individuals low in valence focus describe their emotional experiences in a more differentiated manner, and distinguish between different emotion concepts with the same valence (Barrett, 1998, 2006). Such descriptions may also be used to characterize the distinctions between the nuanced, multi-dimensional GEMS model (highly specific verbal labels, such as nostalgia and wonder), and simpler models such as the two-dimensional circumplex model (broad labels, such as pleasant and unpleasant). Thus, it could be speculated that individuals differing in emotional granularity or valence focus also differ in the way they use different emotion models to describe their emotional responses to music. In the present study, this issue is addressed by exploring the possible contribution of individual difference variables such as personality (the "Big Five" personality traits and empathy) and mood. Perhaps some emotion models might reflect individual differences more strongly than others, and perhaps the applicability of different models depends – to some extent – on individual difference variables.

The first aim of the present study was to compare the applicability of three different emotion models – the discrete emotion model, the three-dimensional model, and the GEMS – in the measurement of music-induced emotions. The second aim was to explore the role of personality and mood in emotional responses to music, with regard to the musical excerpts and the emotion model used. Finally, the third aim was to investigate how the descriptive labels provided by the different emotion models relate to the intensity of experienced emotions. In provocative terms, it could be speculated that if one is required to describe one's emotional responses using inapplicable emotion concepts, the discrepancy between one's experienced emotions and the scales used to describe them may detract from the actual emotional experience, which could be reflected in the ratings of emotional intensity. Thus, ratings of "intensity of experienced emotion" were collected from all participants, including a control group that did not use any other verbal labels to describe their responses.

Method

Participants

The participants were 148 Finnish university students aged 18–49 years ($M = 23.5$, $SD = 4.84$; 77.1% females).

Stimuli and measures

Film music was used as stimulus material, since it is composed for the purpose of mediating powerful emotional cues, and it could serve as an ecologically valid and diverse stimulus material. The stimuli were 16 film music excerpts, ranging from 45 to 77 seconds in length (M = 57.13 s, SD = 9.74). These excerpts were selected on the following basis: using previously obtained valence and arousal ratings (Eerola & Vuoskoski, 2011), the excerpts were selected evenly from the 4 quadrants of the two-dimensional valence-arousal space: 4 excerpts from each quadrant. This resulted in 4 scary, 4 happy, 4 sad, and 4 tender excerpts. Since the original excerpts were too short (15 s) for emotion induction (for a review of music and emotion studies, see Eerola & Vuoskoski, submitted), longer excerpts (approx. 60 s) from the same pieces were taken, ensuring that the emotional characteristics of the original excerpts did not change during the longer versions. In the cases where the expression of a certain emotion did not last long enough (or did not continue in a satisfactory manner), the original excerpts were looped using cross-fading (see Appendix A for the list of excerpts). These new, longer excerpts were then tested in a pilot experiment, where 18 participants (mean age 27.17 years, SD = 6.58; 61.1% females) rated the emotions expressed by the excerpts. The correlations between the mean ratings for the original and the new, longer excerpts were .97 for valence and .97 for arousal, confirming that the new excerpts represented the intended emotion quadrants. Details relating to the stimuli (mean ratings and audio examples) can be found online at www.jyu.fi/music/coe/materials/emotion/soundtracks-1min/.

The Big Five Inventory (BFI; John & Srivastava, 1999) was used to assess the participants' personality traits. The BFI has 44 items that measure five broad personality domains labelled extraversion, agreeableness, conscientiousness, neuroticism, and openness to experience.

The items were rated on a 5-point Likert scale (1 = disagree strongly, 5 = agree strongly). Empathy was assessed using the Interpersonal Reactivity Index (IRI; Davis, 1980), which taps into four separate aspects of the global concept of empathy: fantasy, perspective-taking, empathic concern, and personal distress. The participants had filled in the Big Five Inventory prior to the listening experiment, and the Interpersonal Reactivity Index was sent to the participants after the experiment. In all, 131 participants (88.5% of the total number of participants) returned the IRI. In addition, the UWIST Mood Adjective Checklist (UMACL; Matthews, Jones, & Chamberlain, 1990) was used to measure the participants' current mood prior to the experiment.

Procedure

The listening experiments were conducted individually for each participant in a soundproof room. To gather the emotion ratings, a special patch was designed in MAX/MSP graphical programming environment (version 5.1), running on Mac OS X. The patch presented the music excerpts in a different random order to each participant, and enabled the participants to move from one excerpt to the next at their own pace. Participants listened to the excerpts through studio quality headphones and were able to adjust the sound volume according to their own preferences.

The participants were instructed to rate the emotions that the music evoked in them, and the difference between perceived and felt emotions was explained to them. They were also told that the music might not evoke any emotions in them, and they were able to indicate whether the music evoked an emotional response or not by rating the intensity of their response. In the experiment patch, the scale measuring the intensity of emotional responses was labelled as "the strength of experienced emotion", where 1 signified "no emotion experienced" and 7 signified "very strong". The participants were divided into 4 groups; Group 1 (n = 46) only evaluated the intensity of their emotional responses (i.e., strength of experienced emotion) and how much they liked each excerpt, thus acting as a control group, whereas the other groups could also describe their potential emotional responses using different scales. Group 2 (n = 34) used discrete emotion scales (sadness, happiness, tenderness, fear, and anger), Group 3 (n = 35) used 6 unipolar scales (each represented by two adjectives) derived from the three-dimensional emotion model (positive and negative valence, high and low energy, and high and low tension; Schimmack & Grob, 2000), and Group 4 (n = 33) used the 9 scales (each represented by two or three adjectives) of the music-specific GEMS-9 emotion model (wonder, transcendence, power, tenderness, nostalgia, peacefulness, joyful activation, sadness, and tension; Zentner et al., 2008). The participants were instructed to describe their felt emotions using as many adjective scales as they found appropriate. All emotion ratings were done on 7-point Likert scales.

Results

Model comparison

Scale consistencies. In order to compare the consistency of ratings obtained with the different emotion models, Cronbach alphas and intra-class correlations were calculated for each scale in every model. Although emotional responses to music can potentially be highly subjective, the comparison of the inter-rater agreements can point us towards those models or scales where individual differences might play a more substantial role. The Cronbach alphas and intra-class

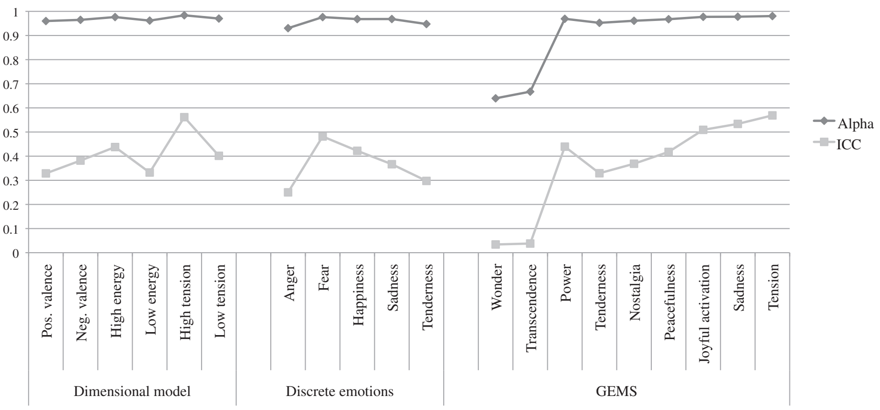

Figure 1. Intraclass correlations (ICC) and Cronbach alphas for all scales in every model.

correlations for every scale are displayed in Figure 1. As the figure illustrates, there were weak and strong scales in every model, and the GEMS-model possessed both the weakest and some of the strongest scales among all three models. The scales with the lowest consistencies were the wonder and transcendence scales of the GEMS-model (α .64, .67; ICC .03, .04), whereas the ratings of high tension (dimensional model) and tension (GEMS-model) had the highest consistencies (α .98, .98; ICC .56, .57). The low consistencies of the wonder and transcendence scales might either reflect the subjectivity of these types of responses, or that the concepts were inapplicable or unclear for the participants. Another explanation might be that the musical material used as stimuli was not able to evoke these types of responses in the participants. However, this seems unlikely, as the mean ratings of wonder and transcendence for all 16 excerpts were 2.46 and 2.14, whereas the overall mean of all GEMS scales was 2.26.

The overall consistency of the three-dimensional model (mean alpha .97; mean ICC .41) was higher than the consistencies of the discrete (.96; .36) and GEMS-9 (.90; .36) models. The pattern of results resembles those obtained by Zentner et al. (2008), except that in the present study the scale consistencies were more uniform across models. The higher overall consistencies of the discrete and dimensional models probably stem from the choice of more relevant items for the discrete and dimensional models, as well as the selection of emotionally varied (and previously validated) stimuli.

Discrimination of music excerpts. Cluster analysis was used to compare the discriminative power of the three models. A model that most reliably captures the variety and range of emotions evoked by music should have a higher power of discrimination and should provide coherent clusters of excerpts. In order to do justice to the dimensional model, the six unipolar scales (positive and negative valence, high and low energy, and high and low tension) were transformed into three bipolar dimensions (valence, energy, and tension) by deducting the mean ratings of negative valence from the mean ratings of positive valence and so forth. This is a standard procedure when collecting data using the three-dimensional model of affect (Schimmack & Grob, 2000; Schimmack & Reisenzein, 2002). The correlations between the two unipolar scales representing each dimension were between −.86 and −.95, supporting the notion that the three dimensions are indeed bipolar.

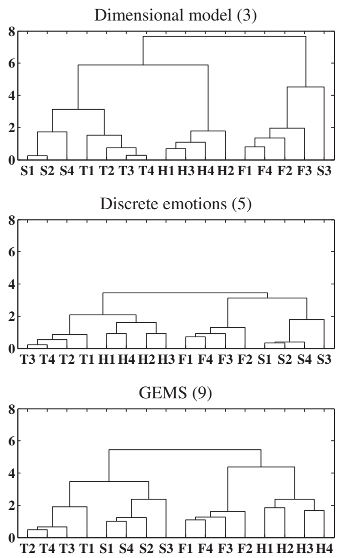

Figure 2. The cluster solutions for the three emotion models showing the clustering of the 16 music excerpts (scary excerpts F1–4, happy excerpts H1–4, sad excerpts S1–4, and tender excerpts T1–4; see Appendix A for the list of stimuli).

Clustering of the 16 music excerpts was performed using average linkage method and Euclidean distances. The mean emotion ratings given in response to each excerpt (on all scales) were used in the analysis. The resulting cluster solutions for the three emotion models are shown in Figure 2. The discriminative power of the cluster solutions was evaluated using aggregated distances (within a cluster solution), which were also used by Zentner et al. (2008) to compare the discriminative accuracy of the three models. The aggregated distances for the dimensional, discrete, and GEMS models were 33.4, 19.2, and 30.9 (respectively), the dimensional model having the largest distances between excerpts and thus the highest discriminative accuracy. These differences are also illustrated in Figure 2.

The qualitative aspects of the cluster structures are also revealing (see Figure 2). The discrete and GEMS models both cluster all 4 examples of each emotion into distinct low-level branches, but the main difference is that in the cluster solution of the GEMS model these branches are organized in terms of arousal (one mid-level branch for all tender [T1–4] and sad excerpts [S1–4], and a separate branch for scary [F1–4] and happy excerpts [H1–4]). In the cluster solution of the discrete emotion model, however, the mid-level branches seem to be organized according to valence. Interestingly, in the cluster solution of the dimensional model, the branch containing all scary excerpts also has a single sad excerpt, which was not evident in the cluster solutions of the other models. In addition, the three remaining sad excerpts were clustered close to the tender excerpts, clearly separated from the cluster of happy excerpts, and even more so from the scary (plus one sad) excerpts. This pattern appears to be reflecting both arousal and valence, and it brings forth the interesting fact that the participants reported experiencing positive (rather than negative) valence in response to three of the sad excerpts, but negative valence in response to one of the sad excerpts (and all of the scary excerpts). Thus, the cluster containing the scary excerpts and one sad excerpt represents the only group of excerpts that evoked negative valence in the participants.

If we consider the economy of the models by taking into account the number of parameters (dimensions or emotion categories) within each model, this provides another perspective on the discriminative power of the models (Lee, 2001). When Bayesian Information Criterion (Schwarz, 1978) is applied to the predictive power of the cluster solutions (using cophenetic correlation, which compares the cluster structure with the original distance matrix), the information theoretic values clearly favor the simplest model, the three-dimensional model. The Bayesian Information Criterion values for the dimensional, discrete, and GEMS models were −35.1 (with 3 predictors), −30.5 (5 predictors), and −18.5 (9 predictors) respectively, illustrating that the simplest models are in this case the most efficient ones, since the lower values indicate better overall model performance.

In sum, the three-dimensional emotion model seems to have superior discriminative power, especially when both the accuracy and simplicity of the models are considered. However, these results are naturally dependent on the musical material used, which in this case may favour the dimensional model. Furthermore, one may ask whether the discrete and GEMS models could be simplified in order to perform better in terms of economy and predictive accuracy. This issue is explored next.

Model reduction. In order to examine the possible collinearity and correspondence of the scales in all three models, a principal component analysis was conducted using the mean ratings for each excerpt. The analysis yielded 3 principal components: the first component (with Eigenvalue 13.8) accounted for 55.4% of the variance, the second component (with Eigenvalue 8.6) accounted for 34.5%, and the third component (with Eigenvalue 1.4) accounted for 6%. Since the contribution of the third component was minor and the component itself was difficult to interpret, components 1 and 2 were rotated using varimax rotation. Figure 3 displays the rotated two-dimensional solution, which accounted for 89.9% of the variance. Based on the loadings of the different emotion scales, the two components could be labelled as valence (inverted) and energy – or tension and energy – respectively.

As Figure 3 illustrates, some of the scales in the three models displayed very similar loadings. For example, high tension (dimensional) and tension (GEMS) were mapped next to each other in the principal component space, as were low tension (dimensional) and peacefulness (GEMS), high energy (dimensional) and power (GEMS), tenderness (discrete) and tenderness (GEMS), and sadness (discrete) and sadness (GEMS). This suggests that the three models have scales that measure very similar emotional qualities, and that the GEMS-model appears to combine aspects of the discrete and dimensional models – with the exception of nostalgia, transcendence, and wonder. Another noteworthy observation is that the scales of wonder and transcendence had very low loadings on all the three principal components, which is in line with the finding that these two scales had the lowest consistency of ratings among all three models.

Intensity of experienced emotion. In order to investigate whether the type of scales (GEMS, discrete, or dimensional) the participants used to describe their emotional responses had an effect on the reported intensity of their experienced emotions, we compared the mean intensity ratings of the participants in the four groups. Group 1 served as a control group, as they only rated the intensity of their experienced emotions and how much they liked each excerpt. A 1-way ANOVA followed by multiple comparisons of means (adjusted by Tukey's method) revealed that the participants using discrete emotion scales (Group 2) reported significantly

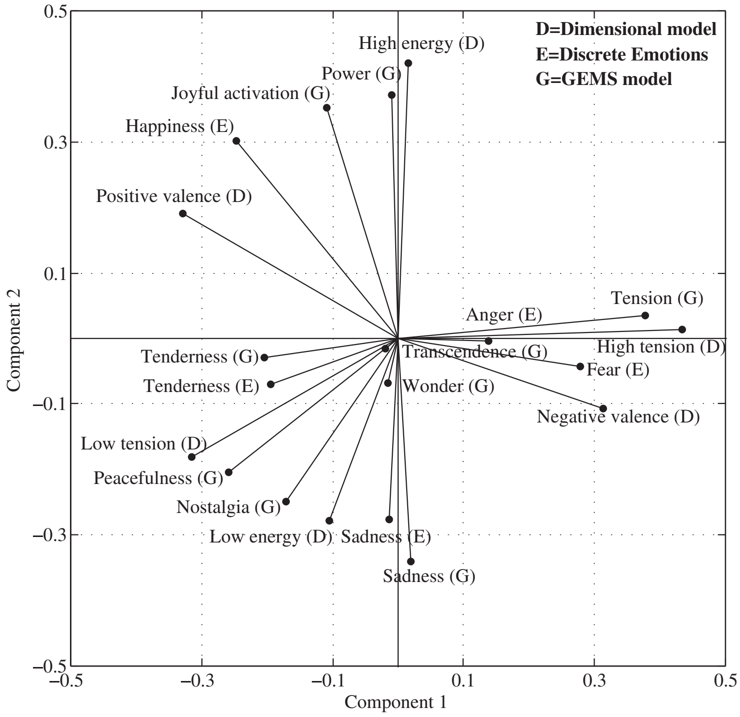

Figure 3. The scales of all three emotion models mapped according to their loadings on the two rotated principal components.

lower intensities of experienced emotion than the other groups: $F(3,144) = 4.83$, $p < 0.01$, $\eta_P^2 = .09$. This suggests that some participants may not have found the discrete emotion scales (anger, fear, happiness, sadness, and tenderness) applicable to their emotional responses, which affected their reported level of intensity. In comparison, the mean intensity ratings of the participants who used dimensional and GEMS scales (groups 3 and 4) did not differ from the intensity ratings of the control group (Group 1).

Individual differences in emotional responses

The effect of rating scales used. Next, we proceeded to investigate whether some emotion models reflect individual differences in emotional responses more strongly than others, and whether the low consistency of ratings is (at least in some cases) the result of these individual differences. Correlation analysis was used to explore whether certain personality traits were related to the experience of certain kinds of music-induced emotions. In the analyses we used mean emotion ratings of each participant, which were calculated from the ratings given in response to all 16 excerpts. There were no statistically significant correlations between personality traits and the mean emotion ratings of the participants using dimensional or GEMS scales, which may partly be due to the small sample size. More specifically, the GEMS scales of wonder and transcendence – which had the lowest consistency of ratings – did not correlate with any of the personality traits or moods under investigation. One might have expected that the trait of openness to experience could play a significant role in these types of responses, as it has previously been associated with the experience of aesthetic emotions such as awe (Shiota, Keltner, & John, 2006). However, in the group using discrete emotion scales, several statistically significant correlations emerged: extraversion correlated positively with experienced happiness ($r = .42$, $p < .05$), sadness ($r = .44$, $p < .01$), and tenderness ($r = .38$, $p < .05$). Extraversion also correlated with the intensity of experienced emotions ($r = .37$, $p < .05$), but only in the group using discrete emotion scales.

Intensity of emotional responses evoked by different types of excerpts. Finally, we investigated whether personality and mood variables were related to the intensity of emotional responses evoked by the different types of excerpts (scary, happy, sad, and tender). In the correlation analyses, we used the mean intensity ratings of all 148 participants for emotions evoked by the four different types of excerpts (note that $n = 131$ in the correlations regarding empathy and its subscales). The personality trait of agreeableness correlated positively with the intensity of emotional responses evoked by tender excerpts ($r = .16$, $p < .05$). Similarly, openness to experience and the empathy-subscale fantasy correlated with the intensity of emotional responses evoked by tender excerpts ($r = .18$ and $r = .19$, $p < .05$) as well as sad excerpts ($r = .17$ and $r = .19$, $p < .05$).

The hedonic tone (i.e., valence) and activity of current mood were both positively correlated with the overall intensity of experienced emotions ($r = .19$ and $r = .17$, $p < .05$). That is, participants in positive and active moods tended to experience more intense emotions in response to the music excerpts. In addition, the hedonic tone of mood was positively connected to the intensity of emotional responses evoked by scary excerpts ($r = .23$, $p < .01$), while the activity of mood was related to higher intensity ratings in response to sad excerpts ($r = .23$, $p < .01$). Interestingly, the third dimension of mood – tension – was negatively correlated with the intensity of emotional responses evoked by happy ($r = -.17$, $p < .05$) and tender ($r = -.20$, $p < .05$) excerpts. This suggests that music expressing positive emotions evokes milder emotional responses when the emotions expressed are incongruent with the listener's current mood state. However, this does not appear to be the case with music expressing negative emotions.

Conclusions

Model comparison

The dimensional model outperformed the GEMS and the discrete emotion model in the discrimination of music excerpts, illustrating that the simplest model may often be the most efficient one. In addition, the ratings of music-induced emotions obtained using the dimensional model had the highest overall consistency. The overall consistencies of the GEMS and the discrete emotion model were difficult to rank, but two of the scales in the GEMS model – wonder and transcendence – had substantially lower consistencies than the any of the other scales. In addition, these two scales did not load onto any of the three principal components in the principal component analysis, and they also did not correlate with any of the individual difference variables (such as openness to experience) that might be related to the experience of aesthetic emotions (see, e.g., Shiota et al., 2006). These findings suggest that these two scales – *wonder* and *transcendence* – may be controversial, especially when using types of music other than western classical music. One may ask whether the musical material used as the stimuli in the present experiment was able to evoke these types of responses in participants in the first place. It may be that these two scales tap into those types of strong, aesthetic experiences that only occur under certain circumstances and with very specific types of music. However, the mean ratings of wonder and transcendence (across all excerpts) were comparable to the mean ratings of the other GEMS scales, which suggests that the low inter-rater agreement might result from the subjective nature of these types of responses, or from the subjective definition of the emotion adjectives used to represent the scales. In the present study we used Finnish translations of the English GEMS scales and adjectives (which were originally translated from French adjectives by Zentner et al.), which may have also contributed to the differences in the present findings compared with Zentner et al. (2008).

Although the discrete emotion model had a relatively high consistency of ratings, it was also the weakest model in the discrimination of music excerpts. Most interestingly, those participants who used discrete emotion scales to describe their emotional responses reported significantly lower intensities of experienced emotions than the other participants. This finding suggests that at least some participants did not find the discrete emotion scales applicable to their experienced emotions, which influenced the reported intensity of their emotional responses. In comparison, the reported intensities of the participants using dimensional and GEMS scales were comparable to the intensities reported by the control group that did not use any adjective scales to describe the quality of their responses.

The results of the principal component analysis suggest that there is a great deal of scale redundancy in the GEMS model and the discrete model, as 89.9% of the variance in the mean ratings of all the scales (in all three models) was accounted for by two components that could be labelled as valence (inverted) and energy (or tension and energy). Similarly, Zentner et al. (2008) found that the intercorrelations in the 9 GEMS factors could be accounted for by 3 second-order factors labelled sublimity, vitality, and unease, which bear strong resemblance to the dimensions of valence, energy, and tension (respectively). However, the results of the PCA also indicate that there is some degree of scale redundancy in the three-dimensional model. This finding is supported by a previous study investigating perceived emotions in music (see Eerola & Vuoskoski, 2011), where valence and tension were observed to be highly collinear constructs. Furthermore, judging by the loadings of all the scales on the two principal components, most of the scales in the GEMS model appear to measure emotional attributes that are very similar to scales in the dimensional and discrete models – with the exception of nostalgia, transcendence, and wonder. However, as the two latter scales appear to be rather problematic, the contribution of the music-specific GEMS model to the measurement of music-induced emotions seems to require further investigation.

The results of the present study are somewhat incongruent with the results obtained by Zentner et al. (2008), and suggest that the performance of GEMS might depend on the type of music used. In the present experiment we used film music excerpts expressing emotions that varied in valence and arousal, while Zentner et al. used excerpts of western classical music masterpieces that were potentially effective in inducing sadness, happiness, anger, fear, and some of the novel emotion categories included in GEMS (for details, see Zentner et al., 2008). It has to be taken into consideration that the results of the present study might at least partly reflect the stimuli, which were originally chosen from the four quadrants of valence-arousal space. However, the stimulus selection was based on ratings of perceived emotions, which can be different from felt emotions (see, e.g., Evans & Schubert, 2008; Gabrielsson, 2002; Kallinen & Ravaja, 2006). Another noteworthy difference between the present study and the study by Zentner et al. is that the formulations of the discrete and dimensional models were quite different, and the version of the GEMS used in the present study (GEMS-9; 9 rating scales each represented by 2 or 3 emotion terms) was simpler than the version used by Zentner et al. (43 separately rated emotion terms). As in the present study we aimed to use more conventional formulations of the discrete and dimensional models, we inevitably had a different number of scales in the three models.

Individual differences in emotional responses

Personality-related differences in the experience of music-induced emotions were the most pronounced in the case of the discrete emotion model: the personality trait of *extraversion* was positively related to the experience of happiness, sadness, and tenderness in response to music excerpts, as well as to the overall intensity of emotional responses. The correlation between extraversion and experienced sadness is not in line with personality theory (according to which extraversion is associated with the tendency to experience positive emotions; see, e.g., John & Srivastava, 1999), which complicates the interpretation of the results. One may argue that the familiar discrete emotion concepts might bring out personality-related differences in emotional processing more clearly than the other two models, which are constructed from more abstract and nuanced emotion concepts. However, this interpretation does not account for the affect-incongruent correlation between extraversion and experienced sadness, nor does it account for the finding that extraversion was related to the reported intensity of experienced emotions only in the discrete emotion group, but not in the three other groups (dimensional, GEMS, and control). Therefore another, perhaps more plausible explanation might be that some people find the discrete emotion concepts more applicable to their emotional responses (to music) than other people do. According to Barrett (1998, 2006), people differ in terms of the level of detail they use to describe and define their emotional experiences. Furthermore, personality traits related to valuation sensitivity, namely extraversion and neuroticism, are associated with high valence focus (i.e., the tendency to use emotion terms such as "angry", "sad", and "nervous" interchangeably to indicate negative feeling; Barrett, 2006). It may be that in comparison to other participants, extraverted participants found the discrete emotion scales more applicable to their experienced emotions, perhaps reflecting high valence focus. This interpretation is further supported by the finding that the mean intensity of emotional responses was significantly lower in the group using discrete emotions to describe their responses, suggesting that some participants may have found the discrete emotion scales inapplicable to their emotional responses.

Certain personality traits and mood states were also related to the intensity of emotional responses evoked by different types of excerpts. Agreeableness was connected with the intensity of emotional responses evoked by tender excerpts, which is in line with the definition of agreeableness as a prosocial trait (see, e.g., John & Srtivastava, 1999). The positive correlation between agreeableness and the intensity of emotional responses evoked by tender music can be interpreted as a form of trait-congruence, reflecting the tendency of agreeable people to be altruistic, tender-minded, and trustful (see, e.g., John & Srtivastava, 1999). Similarly, the connection between the empathy-subscale fantasy and the intensity of emotional responses evoked by tender and sad excerpts can be seen to reflect an empathic individual's tendency to experience feelings of warmth, compassion, and concern for others undergoing negative experiences (see, e.g., Davis, 1980). More specifically, the fantasy scale taps into the tendency to transpose oneself imaginatively into the feelings and actions of fictitious characters in books and films (Davis, 1980), and thus it could be speculated that the trait also facilitates emotional contagion from music – one of the mechanisms through which music is thought to induce emotions (Juslin & Västfjäll, 2008).

The trait of openness to experience was also positively connected with the intensity of emotional responses evoked by tender and sad excerpts. One of the definitions of openness to experience is the sensitivity to art and beauty (McCrae & Sutin, 2009), which may at least partly explain the trait's involvement in the intensity of responses evoked by tender and sad excerpts. Openness to experience has also been found to play an important role in the enjoyment of sad music – together with empathy (Vuoskoski, Thompson, McIlwain, & Eerola, submitted). Furthermore, studies investigating the role of personality in music genre preferences have associated openness to experience with the preference for "reflective and complex" music styles (e.g., Rentfrow & Gosling, 2003), which further supports the interpretation that this trait might be related to the aesthetic appreciation of music.

Finally, positive and active moods were related to higher overall intensity of experienced emotions. A similar finding was reported by Dibben (2004), who found that high arousal (induced physiological arousal) was connected with higher intensity of emotional responses evoked by music. Thus, the connection between active mood and experienced intensity might be at least partly explained by the higher arousal level of active mood states. Positive mood also correlated with the intensity of emotional responses evoked by scary excerpts, while active mood correlated with the intensity evoked by sad excerpts. One explanation for these findings may be that the participants in negative and tired moods tried to repair their mood (see, e.g., Isen, 1985) and did not let themselves be absorbed in music expressing negative emotions. Another explanation involves the intriguing notion that music-induced emotions may be somewhat different from everyday emotions. For example, even if scary excerpts evoke intense emotional responses in listeners, the experienced emotion might not be fear (or any other clearly unpleasant emotion; see, e.g., Gabrielsson, 2002). This interpretation is rendered even more interesting by the finding that music expressing *positive* emotions evoked milder emotional responses when it was incongruent with the listener's current mood state (a finding consistent with the mood-congruency literature), whereas music expressing *negative* emotions functioned in an opposite manner. Perhaps the emotions evoked by music expressing "negative" emotions are indeed fundamentally different from everyday negative emotions, as they appear to function in a manner different from that described in the mood-congruency literature. This conclusion, however, requires further study, as the present study has examined the issue only briefly.

In summary, although the GEMS may provide more nuanced information about musically induced emotions (especially in situations where strong, aesthetic emotions are experienced), the dimensional model appears to be the most efficient and reliable way of collecting and representing musical emotion data. Conversely, the discrete emotion model appears to be the most problematic model in the measurement of music-induced emotions, as it had significantly lower discriminative accuracy than the other two models, and it also appeared to attenuate the reported intensity of experienced emotions. There were also individual differences in the use of the discrete emotion model, as extraverted participants seemed to find the discrete emotion scales more applicable to their experienced emotions than the other participants. Furthermore, certain personality traits (agreeableness, openness to experience, and the empathy-subscale fantasy) and mood states were associated with the intensity of emotional responses evoked by different types (scary, happy, tender, and sad) of excerpts. Perhaps the most intriguing direction for future research would be to explore further how music-specific and general emotion models are connected to individual differences in music-induced emotions, and to identify the range of listener features that contribute to these differences.

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Appendix A

List of stimuli used to induce emotions

Excerpt	Emotion	Soundtrack name	Track	Time	Duration	Number in the set of 110**
F1	Scary	The Alien Trilogy	9	00:00-00:56	56 s	003
F2	Scary	Batman Returns	5	00:00-00:46	46 s	011
F3	Scary	The Fifth Element	17	00:00-01:01	61 s	018
F4	Scary	The Alien Trilogy	11	02:04-02:58	54 s	091
H1	Happy	Oliver Twist	8	01:32-02:09 L*	72 s	027
H2	Happy	Dances with Wolves	10	00:00-00:46	46 s	055
H3	Happy	The Untouchables	6	01:26-02:06 L*	67 s	071
H4	Happy	Pride & Prejudice	4	00:10-01:06	56 s	105
S1	Sad	The English Patient	18	00:00-00:59	59 s	031
S2	Sad	The Portrait of a Lady	9	00:00-00:23 L*	45 s	033
S3	Sad	Running Scared	15	01:45-02:40	55 s	086
S4	Sad	Pride & Prejudice	13	00:40-01:30	50 s	109
T1	Tender	The Portrait of a Lady	3	00:23-01:08	45 s	029
T2	Tender	Shine	10	01:01-02:00	59 s	041
T3	Tender	Pride & Prejudice	1	00:10-00:49 L*	77 s	042
T4	Tender	The Godfather III	5	01:13-02:19	66 s	107

*L = looped
**see the list of stimuli for the set of 110 excerpts, Eerola & Vuoskoski, 2011

IV

WHO ENJOYS LISTENING TO SAD MUSIC AND WHY?

by

Jonna K. Vuoskoski, William F. Thompson, Doris McIlwain & Tuomas Eerola, 2012

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WHO ENJOYS LISTENING TO SAD MUSIC AND WHY?

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ALTHOUGH PEOPLE GENERALLY AVOID NEGATIVE EMOTIONAL experiences in general, they often enjoy sadness portrayed in music and other arts. The present study investigated what kinds of subjective emotional experiences are induced in listeners by sad music, and whether the tendency to enjoy sad music is associated with particular personality traits. One hundred forty-eight participants listened to 16 music excerpts and rated their emotional responses. As expected, sadness was the most salient emotion experienced in response to sad excerpts. However, other more positive and complex emotions such as nostalgia, peacefulness, and wonder were also evident. Furthermore, two personality traits – *Openness to Experience* and *Empathy* – were associated with liking for sad music and with the intensity of emotional responses induced by sad music, suggesting that aesthetic appreciation and empathetic engagement play a role in the enjoyment of sad music.

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Key words: sadness, music-induced emotions, openness to experience, empathy, preference

ALTHOUGH PEOPLE AVOID EXPERIENCING NEGATIVE emotions in their daily lives, many people get enormous enjoyment from sad music such as *Greensleeves* or a Chopin nocturne. The appeal of such music illustrates one of the most intriguing questions in the history of music scholarship: Why do people enjoy listening to music that evokes sadness? The paradox of "pleasurable sadness" has puzzled music scholars for decades (e.g., Levinson, 1997). However, little empirical work has been done to date to document the emotions that listeners actually experience while listening to sad music. Instead, investigations on the topic have mainly been limited to philosophical discussions (e.g., Kivy, 1990; Robinson, 1994).

In a recent questionnaire study, Garrido and Schubert (2011) investigated the role of individual differences in the reported enjoyment of sad music. They found that *Absorption* (see Tellegen & Atkinson, 1974) and *Music Empathizing* (see Kreutz, Schubert, & Mitchell, 2008) were the best predictors of the enjoyment of sadness-inducing music. They suggested that "dissociation" from pain or displeasure as a cognitive mechanism is at the core of the phenomenon – a conclusion built on a theory proposed by Schubert (1996), according to which an aesthetic context activates a node that inhibits the "displeasure centre" associated with negative emotions, and that feelings of pleasure arise from the mere process of activation. However, their conclusions about the role of dissociation may be premature, as their study design and results leave alternative explanations open. First, they only investigated preference for sadness-inducing music, and not preference for music expressing or eliciting other negative emotions. Thus, we do not know whether the dissociation theory also applies to music expressing anger or fear, for example. Second, they did not investigate what kinds of felt emotions people actually experience in response to sadness-inducing music (or in response to other types of music). This information could prove to be crucial in elucidating why some people enjoy listening to sadness-inducing music.

Investigating the enjoyment of cinematic tragedy, De Wied, Zillmann, and Ordman (1994) discovered that people experiencing more empathic distress during the film also enjoyed the film more than low empathizers did. They suggested that tragedy may inspire a more complex response than just sadness – including positive emotions – via the portrayal of close friendship, love, bravery, and human perseverance. Another relevant finding comes from a study by Eerola and Vuoskoski (2011), in which 116 participants evaluated 110 film music excerpts in terms of perceived emotions, preference, and beauty. Beauty ratings correlated strongly with sadness ratings ($r = .59$, $p < .001$) but not with happiness ratings ($r = .16$, *ns*), suggesting that

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aesthetic appreciation and beauty may play a significant role in the enjoyment of sad music.

To explore this intriguing possibility further, we asked simple questions: First, what kinds of subjective emotional experiences do sad music induce in listeners? Second, is the tendency to enjoy sad music associated with particular personality attributes? Because the complexity of emotional response was of particular concern, we used three sets of emotional rating scales representing different theories of emotion; discrete emotions, three-dimensional model, and the Geneva Emotional Music Scale, which is specifically designed to measure a wide range of music-induced emotions (Zentner, Grandjean, & Scherer, 2008).

If sad music indeed evokes complex, aesthetic emotions (see e.g., Scherer, 2004), such experiences may be especially appealing to individuals with certain personalities. The trait *Openness to Experience* is related to a sensitivity to art and beauty (McCrae & Sutin, 2009), to a preference for diverse and complex music styles (e.g., Rentfrow & Gosling, 2003), and to the experience of aesthetic chills in response to music (Nusbaum & Silvia, 2011). The trait *Empathy* also has been implicated in vicarious responses to aesthetic experiences. In its broadest sense, *Empathy* is defined as an individual's responsivity to the observed experiences of another, involving both cognitive and affective components (Davis, 1980). Empathic distress has previously been associated with greater enjoyment of sad films (De Wied et al., 1994). Additionally, empathy and its "hot" subcomponent emotional contagion have also been mentioned as possible mechanisms through which music can induce emotions (Juslin & Västfjäll, 2008). So our second question addressed whether *Openness to Experience* and *Empathy* were related to the enjoyment of sad music.

Method

PARTICIPANTS

The participants were 148 Finnish university students from different faculties aged 18-49 years (mean = 23.50, *SD* = 4.84, 77.08% females).

STIMULI AND MEASURES

The stimuli were 16 film music excerpts[1] with normatively verified emotional tone (four each of scary, happy, sad, and tender; see Appendix for the list of excerpts), ranging from 45 to 77 s in length (mean = 57.13, *SD* = 9.74). These excerpts were selected from a set of 110 with empirically established emotion and familiarity ratings (Eerola & Vuoskoski, 2011). In order to minimize the possibility of extramusical associations, only excerpts rated as unfamiliar were chosen for the present study. Longer versions of the original 15-s excerpts were taken and tested in a pilot experiment. Twelve participants (mean age = 24.67 years, *SD* = 2.27, 58.33% females) rated the emotions expressed by the excerpts using discrete emotion scales (sadness, happiness, anger, fear, and tenderness). Repeated measures ANOVAs and multiple comparisons of means (Tukey) confirmed that the excerpts conveyed the intended emotions (all post hoc comparisons were significant at .01 level).

The Big Five Inventory (BFI; John & Srivastava, 1999) was used to assess the personality trait *Openness to Experience*. *Empathy* was assessed using the Interpersonal Reactivity Index (IRI; Davis, 1980), which taps into four separate aspects of the global concept of *Empathy*: *Fantasy, Perspective-taking, Empathic Concern,* and *Personal Distress*.

PROCEDURE

The listening experiments were conducted individually using a computer interface and studio quality headphones. The participants had filled in the BFI prior to the listening experiment, and the IRI was sent to the participants after the experiment. One hundred and thirty one participants (88.51%) returned the IRI.

The participants received the following instructions: "Concentrate on listening to the music. After each music excerpt, evaluate what kinds of emotions the music evoked in you. The music may not necessarily evoke any emotions in you, so please try carefully to separate your own feelings from the emotions expressed by the music. First, rate the intensity of your emotional response in general, and then describe your felt emotion with the adjective scales below. You should also rate how much you liked each excerpt. After you have completed the ratings, you can move to the next excerpt by pressing 'next.'"

There were four groups of participants. Group 1 (*n* = 46) only evaluated the intensity of their emotional responses and how much they liked each excerpt. The other groups could also describe their potential emotional responses using different scales. Group 2 (*n* = 34) provided ratings for five discrete emotions (sadness, happiness, tenderness, fear, and anger). Group 3 (*n* = 35) provided ratings for six unipolar scales derived from the three-dimensional emotion model (positive and negative valence, high and low energy, and high and low tension; Schimmack & Grob, 2000) and Group 4 (*n* = 33) for the nine scales of the music-specific GEMS-9 (wonder, transcendence, power, tenderness, nostalgia, peacefulness, joyful activation, sadness, and tension;

[1] Details relating to the stimuli (mean ratings and audio examples) can be found online at https://www.jyu.fi/music/coe/materials/emotion/soundtracks-1min/

Zentner et al., 2008). All ratings were done on scales from "1" ("not at all") to "7" ("very much").

Results

EMOTIONS EXPERIENCED IN RESPONSE TO SAD EXCERPTS

Repeated measures ANOVAs followed by multiple comparisons of means (adjusted by Tukey's method) were carried out to analyze the emotion ratings obtained with the discrete emotion and GEMS scales. In the case of discrete emotions, the ratings of experienced sadness (in response to sad excerpts) were significantly higher than the ratings of any other emotion: $F(4, 132) = 46.50$, $p < .001$, η^2_G (generalized eta squared; Bakeman, 2005) = .46. All post hoc comparisons between sadness and other discrete emotions were significant at the .001 level. In the case of the GEMS model, the ratings of experienced sadness were significantly higher than those for all other emotions – except nostalgia: $F(8, 256) = 59.38$, $p < .001$, $\eta^2_G = .53$. The post hoc comparisons between sadness and other GEMS scales (except nostalgia) were significant at the .001 level. Although the participants reported experiencing sadness more than any other emotion (in response to sad excerpts), other more complex and positive feelings – such as nostalgia, peacefulness, and wonder – were also clearly evident in the ratings of the participants using the more nuanced GEMS scales. The mean GEMS ratings in response to sad excerpts are illustrated in Figure 1.

In order to determine whether the nuanced emotional responses to sad excerpts were experienced overall as positive or negative, we examined the valence ratings obtained with the three-dimensional emotion model. The ratings of positive valence were somewhat higher than the ratings of negative valence, but a two-tailed, paired *t*-test revealed that overall, the emotions evoked by sad excerpts were rated as neither negative nor positive, $t(34) = 1.49$, $p = ns$. The mean ratings for positive and negative valence were 3.03 ($SD = 1.83$) and 2.48 ($SD = 1.67$), respectively. A similar analysis for scary excerpts yielded different results, as emotional responses to scary excerpts were rated as clearly unpleasant, $t(34) = -4.11$, $p < .001$. The mean ratings for positive and negative valence were 2.12 ($SD = 1.53$) and 3.78 ($SD = 2.13$). In comparison, the emotions evoked by tender and happy excerpts were rated as clearly pleasant, $t(34) = 11.98$, $p < .001$ and $t(34) = 13.99$ $p < .001$, respectively.

LIKING AND INTENSITY RATINGS FOR THE DIFFERENT TYPES OF EXCERPTS

A repeated measures ANOVA and multiple comparisons of means were conducted to compare liking ratings for sad excerpts with liking ratings for the other types of excerpts (see Figure 2 for the mean liking and

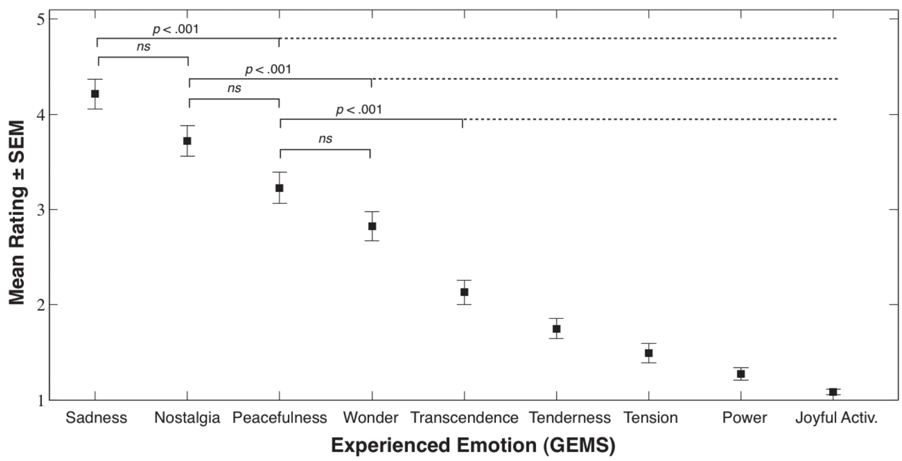

FIGURE 1. Mean GEMS ratings and standard errors for emotions experienced in response to sad excerpts, and the results of multiple comparisons of means (adjusted by Tukey's method).

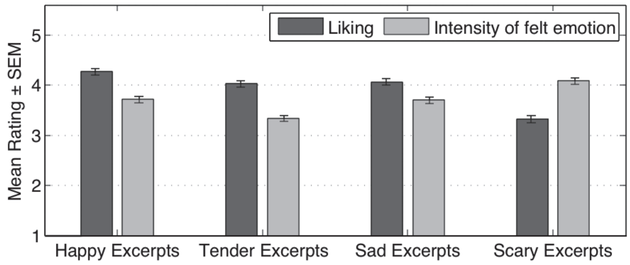

FIGURE 2. Mean ratings of liking and intensity of felt emotion (+ or – standard error of the mean) for the different types of excerpts.

intensity ratings for the different types of excerpts). There were no significant differences in the liking ratings for sad, happy, and tender excerpts, but scary excerpts were significantly less liked; $F(3,441) = 37.47$, $p < .001$, $\eta^2_G = .15$. The post hoc comparisons between scary excerpts and other types of excerpts were significant at the .001 level. However, scary excerpts also evoked the most intense emotional responses in the participants; $F(3,441) = 27.96$, $p < .001$, $\eta^2_G = .10$. The post hoc comparisons between scary and other types of excerpts were significant at the .001 level.

OPENNESS TO EXPERIENCE, EMPATHY, AND LIKING FOR SAD EXCERPTS

Finally, we explored the question of whether the tendency to enjoy sad music is associated with particular personality traits. Correlation analysis, summarized in Table 1, revealed that both *Openness to Experience* and global *Empathy* were significantly connected with liking for sad excerpts, $r(146)= .21$ and $r(129) = .26$, both $p < .01$. As a control measure, we also investigated whether the traits correlated with liking for the other types of excerpts.

TABLE 1. Correlations Between Personality Factors and Mean Liking Ratings for the Different Types of Excerpts

	Mean Liking Ratings			
	Sad	Happy	Scary	Tender
Openness to Experience	.21**	−.04	.12	.14
Global Empathy	.26**	.01	−.06	.32***
Fantasy	.28**	.10	.10	.34***
Perspective Taking	.09	−.08	−.14	.15
Empathic Concern	.23**	.01	−.13	.25**
Personal Distress	.05	−.01	.01	.07

*$p < .05$, **$p < .01$, ***$p < .001$

Openness to Experience did not correlate with liking for scary, happy, or tender excerpts, but *Empathy* correlated with liking for tender excerpts, $r(129) = .32$, $p < .001$. A closer look at the four subscales of *Empathy* revealed that only two of the subscales – *Fantasy* and *Empathic Concern* – were significantly correlated with liking for sad music, $r(129) = .28$, and .23, both $p < .01$. The *Fantasy* scale taps into the tendency to imaginatively transpose oneself into the feelings and actions of fictitious characters, while the *Empathic Concern* scale assesses the degree to which one experiences feelings of compassion and concern for others undergoing negative experiences (Davis, 1980).

Further analysis revealed that *Openness to Experience* and *Fantasy* also correlated with the intensity of emotions experienced in response to sad excerpts, $r(129) = .17$ and .19, both $p < .05$. It should also be noted that the intensity of emotions experienced in response to sad excerpts correlated strongly with liking ratings, $r(146) = .57$, $p < .001$, suggesting a link between intensity of felt emotion and liking. Global *Empathy* and *Openness to Experience* were also related to experienced positive valence in response to sad excerpts, $r(33) = .38$, $p < .05$ and $r(33) = .32$, $p = .065$, which further suggests that those who are empathetic and "open" experience greater enjoyment in response to sad music.

Discussion

Our results uncover the complexity of emotional responses to sad music, showing they are not experienced as negative or unpleasant, unlike most experiences of sad real-life events. Although sadness was the most salient emotion experienced (in response to sad excerpts), other emotions such as nostalgia, peacefulness, and wonder were also clearly evident. These other emotions can be characterized as positive and pleasurable (see Zentner et al., 2008). Our results suggest that the enjoyment of sad music cannot be fully explained by the dissociation theory (Garrido & Schubert, 2011; Schubert 1996), as the emotional responses to scary excerpts were certainly rated as unpleasant. If dissociation from pain and displeasure should indeed take place in an aesthetic context, it does not explain why sad music is enjoyed while scary music is not. Instead, we propose that the enjoyment of sad music may stem from an intense emotional response combined with the aesthetic appeal of sad music. Three findings support this interpretation. First, sad music evoked, in addition to sadness, a range of positively toned, aesthetic emotions (see e.g., Scherer, 2004; Zentner et al., 2008). Second, those most able to appreciate aesthetic experiences and beauty – those highest in the trait *Openness to Experience* – most liked sad music. Third, those who experienced the most intense emotions in response to sad music – including participants scoring high in the trait *Empathy* – also enjoyed sad music the most.

Although scary music induced the most intense emotional responses in listeners, those responses were rated as significantly unpleasant. Evidence from previous studies suggests that the most evident difference between sad and scary music is related to their aesthetic appeal. In a study of 110 music excerpts (Eerola & Vuoskoski, 2011), ratings of perceived sadness had a high positive correlation with ratings of perceived beauty ($r = .59$, $p < .001$), while fear and anger ratings had high negative correlations with beauty ratings ($r = -.73$ and $r = -.56$ both $p < .001$). However, it should be noted that aesthetic responses are highly subjective (for a recent discussion on aesthetic responses to music, see Huron, 2009), and thus it is possible that only some people find sad music beautiful, or scary music ugly.

Our interpretation is consistent with the findings – though not with the conclusions – of Garrido and Schubert (2011), who found that *Absorption* (but not clinical *Dissociation*) and *Music Empathizing* were reliable predictors of the enjoyment of sad music. Our results suggest that – as in the case of tragic films (De Wied et al., 1994) – sad music may induce stronger emotional responses in empathic listeners, which in turn leads to greater enjoyment. This may also be the case for listeners scoring high on *Absorption,* as *Absorption* has previously been associated with stronger felt emotions (and felt sadness in particular) in response to music (Kreutz, Ott, Teichmann, Osawa, & Vaitl, 2008), and it is also related to a tendency to empathize with objects of attention (Tellegen & Atkinson, 1974). Other studies have also found that *Absorption* and *Openness to Experience* are highly correlated traits, reflecting a similar tendency to appreciate aesthetic experiences and fantasize (Glisky, Tataryn, Tobias, Kihlstrom, & McConkey, 1991; Wild, Kuiken, & Schopflocher, 1995). The dissociation theory also implies that the sadness induced by sad music is different from sadness experienced in everyday life. However, a recent study suggests that sad music can induce similar changes in memory and judgment as the recollection of a sad autobiographical event – especially in empathic listeners (Vuoskoski & Eerola, in press). Further, a number of studies using music as a method of mood manipulation suggest that musically induced affective states are linked with similar behavioral and cognitive changes as those produced by affective states experienced in everyday life (for reviews, see Västfjäll, 2002, 2010).

In summary, the enjoyment of sad music cannot be entirely explained by the dissociation theory (Garrido & Schubert, 2011; Schubert, 1996), as it does not account for the divergent responses to music expressing different negative emotions. The dominant emotion evoked by sad music appears to be interpreted as sadness by the listeners, but such music also evokes a range of more positive, aesthetic emotions. Sad music appealed most to those who have a heightened responsiveness to the experiences of others, who experience intense emotions in response to sad music, and who show enhanced sensitivity to art and beauty.

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APPENDIX. List of Stimuli Used to Induce Emotions

Excerpt	Emotion	Soundtrack name	Track	Time	Duration	Number in the set of 110**
F1	Scary	The Alien Trilogy	9	00:00-00:56	56 s	003
F2	Scary	Batman Returns	5	00:00-00:46	46 s	011
F3	Scary	The Fifth Element	17	00:00-01:01	61 s	018
F4	Scary	The Alien Trilogy	11	02:04-02:58	54 s	091
H1	Happy	Oliver Twist	8	01:32-02:09 L*	72 s	027
H2	Happy	Dances with Wolves	10	00:00-00:46	46 s	055
H3	Happy	The Untouchables	6	01:26-02:06 L*	67 s	071
H4	Happy	Pride & Prejudice	4	00:10-01:06	56 s	105
S1	Sad	The English Patient	18	00:00-00:59	59 s	031
S2	Sad	The Portrait of a Lady	9	00:00-00:23 L*	45 s	033
S3	Sad	Running Scared	15	01:45-02:40	55 s	086
S4	Sad	Pride & Prejudice	13	00:40-01:30	50 s	109
T1	Tender	The Portrait of a Lady	3	00:23-01:08	45 s	029
T2	Tender	Shine	10	01:01-02:00	59 s	041
T3	Tender	Pride & Prejudice	1	00:10-00:49 L*	77 s	042
T4	Tender	The Godfather III	5	01:13-02:19	66 s	107

*L = looped
**see the list of stimuli for the set of 110 excerpts, Eerola & Vuoskoski (2011)

V

CAN SAD MUSIC REALLY MAKE YOU SAD? INDIRECT MEASURES OF AFFECTIVE STATES INDUCED BY MUSIC AND AUTOBIOGRAPHICAL MEMORIES

by

Jonna K. Vuoskoski & Tuomas Eerola, 2012

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Can Sad Music Really Make You Sad? Indirect Measures of Affective States Induced by Music and Autobiographical Memories

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The present study addressed music's disputed ability to induce genuine sadness in listeners by investigating whether listening to sad music can induce sadness-related effects on memory and judgment. Related aims were to explore how the different mechanisms of music-induced emotions are involved in sadness induced by familiar, self-selected music and unfamiliar, experimenter-selected music, and whether the susceptibility to music-induced sadness is associated with trait empathy. One hundred twenty participants were randomly assigned into four conditions with different tasks: listening to unfamiliar sad or neutral music, or to self-selected sad music, or recalling a sad autobiographical event and writing about it. The induced affective states were measured indirectly using a word recall task and a judgment task where participants rated the emotions expressed by pictures depicting facial expressions. The results indicate that listening to sad music can indeed induce changes in emotion-related memory and judgment. However, this effect depends, to some extent, on the music's relevance to the listener, as well as on the personality attributes of the listener. Trait empathy contributed to the susceptibility to sadness induced by unfamiliar music, while autobiographical memories contributed to sadness induced by self-selected music.

Keywords: music-induced emotion, sadness, empathy

It is a commonly accepted notion in the Western culture that music has the ability to both express emotions and induce emotional responses in the listener (see, e.g., Juslin & Sloboda, 2001). However, researchers in the field of music and emotions disagree on what kinds of emotions music can induce in listeners (e.g., Juslin & Laukka, 2004; Konečni, 2008), and whether the responses evoked by music are actually real emotions at all (e.g., Kivy, 1989, 1990; Scherer & Zentner, 2001; Konečni, 2008; Juslin & Västfjäll, 2008). Particularly problematic is the case of sadness, as many people report enjoying sad music despite its negative emotional tone (Garrido & Schubert, 2011; Huron, 2011; Vuoskoski, Thompson, McIlwain, & Eerola, in press). Although people often report experiencing sadness in response to music (Juslin & Laukka, 2004; Juslin, Liljeström, Laukka, Västfäll, & Lundqvist, 2011; Vuoskoski et al., in press), some researchers claim that these people are in fact mistaken about the quality of their experience, and that they confuse their own emotional experience with the emotion expressed by the music (see, e.g., Kivy, 1989; Konečni, 2008). The rationale behind this claim is that since music cannot have any real-life consequences for the listeners' goals or desires, it cannot evoke "real" emotions such as sadness—unless the music triggers memories of emotional events through association (Kivy, 1989, 1990).

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There has been a limited amount of empirical attempts to investigate music's ability to induce genuine emotional responses in listeners (for a review, see Konečni, 2008). As self-reports may be vulnerable to demand characteristics (Orne, 1962), and as some researchers claim that listeners may easily confuse emotional responses to music with emotions expressed by the music (Kivy, 1989, 1990), most of these studies have focused on physiological responses to music expressing different emotions—including sadness. Some studies have reported that sad music can elicit physiological reactions distinguishable from reactions elicited by certain other types of music (e.g., Nyklícek, Thayer, & Van Doornen, 1997; Krumhansl, 1997; Lundqvist, Carlsson, Hilmersson, & Juslin, 2009), while others have found that physiological reactions to music are largely accounted for by musical features such as tempo (Etzel, Johnsen, Dickerson, Tranel, & Adolphs, 2006; Gomez & Danuser, 2007). Therefore, it is difficult to say what the relative contributions of the acoustical and emotional aspects of music to the reported physiological reactions are. Despite the limitations related to self-reports (especially in the context of music-induced emotions), there have also been self-report studies that have addressed music's ability to induce "real" emotions: Using well-known pieces from the Western classical music repertoire, Konečni, Brown, and Wanic (2008) compared the emotional states induced by happy, neutral, and sad music and the recollection of autobiographical events. They found that sad music evoked lower ratings of experienced sadness than the recollection of sad autobiographical events, but happy music lead to ratings that were comparable to the ratings evoked by the recollection of happy events. However, it is premature to conclude that sadness is less intensely induced by music than happiness, since the study design (i.e., only one sad and one happy piece used as stimuli) leaves alternative explanations open.

In addition to a host of studies from the fields of music therapy, music psychology, and music education, some evidence for music's ability to induce affective states comes from studies utilizing music listening (with or without instructions to deliberately change one's mood with the help of music) as a method of "mood manipulation" (for a review, see Västfjäll, 2002). Despite the fact that a number of studies have used music listening to manipulate participants' mood states (see, e.g., Westermann, Spies, Stahl, & Hesse, 1996; Västfjäll, 2002), Juslin and Västfjäll (2008) argue that the affective responses evoked by music are better characterized as emotions rather than moods, since the listeners' responses are focused on an object (the music), their duration is relatively short (ca. 5–40 minutes; see Västfjäll, 2002), and they involve components that are commonly associated with emotions rather than moods. One issue that may have contributed to the debatable use of music listening as "mood-manipulation" is that affect researchers sometimes use the terms *mood* and *emotion* interchangeably—partly because of a lack of empirical evidence regarding emotion–mood distinctions (Beedie, Terry, & Lane, 2005). Furthermore, it is also unclear whether emotions and moods are two distinct phenomena, or whether they actually represent the opposite ends of a single continuum (Beedie et al., 2005). The present study adopts the view that, although the affective responses to music may be better described as emotions rather than moods, clear distinctions cannot be made between the two, as affective processing may be better described as a continuous process (see, e.g., Sloboda & Juslin, 2010).

Some of the so-called mood-manipulation studies have used indirect measures of affective states (for a review, see Västfjäll, 2010), which are based on the premise that affective states like emotions and moods are accompanied by changes in information processing and behavior (see, e.g., Bower, 1981; Russell, 2003), and that music-induced emotional states last longer than the duration of the music piece listened to (see, e.g., Västfjäll, 2002). These indirect measures are relatively free from demand characteristics, and do not rely on the participants' conscious interpretations of their own internal processes (which may not always be accessible on a conscious level; see, e.g., Nisbett & Wilson, 1977). Examples of indirect measures that have been used to study emotional states induced by music include word recall (Clark & Teasdale, 1985), autobiographical recall (Parrot & Sabini, 1990), count time (Clark & Teasdale, 1985), distance estimation (Kenealy, 1988), and emotional picture judgment tasks (Bouhuys, Bloem, & Groothuis, 1995).

Although musical mood-induction studies have shown that music can effectively induce different emotional states in participants (for reviews, see Westermann et al., 1995; Västfjäll, 2002), most of the studies have focused on comparing the effects of happy and sad music (e.g., Clark & Teasdale, 1985; Kenealy, 1988; Parrot & Sabini, 1990), which differ both in arousal and valence. As music's ability to induce happiness is less controversial than its ability to induce sadness (e.g., Konečni et al., 2008), the differentiation between the effects induced by happy and sad music is not enough to suggest that sad music can indeed induce sadness. Perhaps one of the most interesting findings regarding musical mood-induction studies concerns the effectiveness of different types of music: Carter, Wilson, Lawson, and Bulik (1995) found that music selected by the participants themselves was more effective in inducing the intended emotional states than music chosen by the experimenters. This finding highlights the personal relevance of music-induced emotional states, and raises questions about the role of autobiographical memories (or *episodic memories*, see Juslin & Västfjäll, 2008) and subjective associations in music-induced emotions.

Juslin and Västfjäll (2008) have proposed different mechanisms through which music can induce emotions in listeners. These include *brain stem reflexes*, *evaluative conditioning*, *emotional contagion*, *visual imagery*, *episodic memory*, and *musical expectancy*. Apart from a few explorative studies (e.g., Juslin, Liljeström, Västfjäll, Barradas, & Silva, 2008; Juslin et al., 2011), little is known about the prevalence of these suggested mechanisms with regard to different emotions. It may be that some of these suggested mechanisms are more effective than others in inducing sadness, while other mechanisms (e.g., emotional contagion) may interact with personality attributes such as trait empathy. Trait empathy can be defined as an individual's responsivity to the observed experiences of another, involving both perspective-taking capabilities or tendencies, and emotional reactivity (Davis, 1980). Trait empathy has previously been linked with emotional contagion in general (e.g., Doherty, 1997), and it may also contribute to susceptibility to music-induced emotions (see, e.g., Scherer & Zentner, 2001; Vuoskoski & Eerola, 2011).

The present study addresses music's disputed ability to induce genuine sadness in listeners by investigating whether listening to sad music can induce sadness-related effects on memory and judgment. Autobiographical recall has been shown to be one of the most effective ways to induce emotional states (see, e.g., Brewer, Doughtie, & Lubin, 1980; Baker & Gutterfriend, 1993; Jallais & Gilet, 2010), and should thus serve as a valid point of comparison for musically induced emotional states. The memory and judgment effects induced by sad music and sad autobiographical recall will be directly compared to the effects induced by neutral music (rather than happy music). This comparison will naturally be subtler than a comparison with the effects of happy music, but will form a more controlled setting in terms of both valence and arousal. A related aim was to explore how some of the proposed mechanisms of music-induced emotions (namely emotional contagion and episodic memories; Juslin & Västfjäll, 2008) are involved in sadness induced by self-selected music, and unfamiliar, experimenter-selected music. A possible explanation behind the reported superiority of self-selected music in inducing emotional states (Carter et al., 1995) may be that different mechanisms contribute to the emotional states induced by self-selected and unfamiliar music. It may also be that there are individual differences in the susceptibility to music-induced emotions, as mechanisms such as emotional contagion may interact with a person's inherent tendency to experience empathy. Thus, it was also investigated whether the susceptibility to sadness induced by unfamiliar music is associated with trait empathy. The induced emotional states were measured indirectly using a word recall task and a judgment task where participants rated the emotions expressed by facial expression pictures.

According to the associative network theory of affect (Bower, 1981), emotional states bias the interpretation of emotional material—especially ambiguous material—in affect-congruent directions. Previous studies have shown that induced affective states lead to affect-congruent judgment biases in the evaluation of pleasant, unpleasant, and ambiguous slides (Isen & Shalker, 1982) and drawn faces with clear and ambiguous emotional expressions (Bouhuys et al., 1995), for example. In other words, people experiencing a sad emotional state would interpret emotional stimuli as sadder and less happy than people experiencing a neutral or happy emotional state (for a review, see Rusting, 1998).

The associative network theory (Bower, 1981) also postulates that people remember more easily material (such as words or memories) that is affectively congruent with their current emotional state. However, empirical studies have reported inconsistent findings: affect-congruent memory effects, no memory effects, and affect-incongruent memory effects (for reviews, see Matt, Vásquez, & Campbell, 1992; Rusting, 1998). Isen (1985) has suggested that affect-incongruent memory effects stem from participants' instinctive attempts to regulate their moods and emotions. In fact, Parrot and Sabini (1990) demonstrated in a series of experiments that affect-incongruent memory effects emerge in naturalistic conditions where participants are unaware of the relevance of their affective states to the experiment. In contrast, affect-congruent memory effects were observed when the participants were instructed to deliberately change their moods, thus possibly inhibiting their mood-regulation tendencies.

As music and emotion scholars seem to disagree in particular on whether unfamiliar, instrumental music can induce genuine sadness in listeners, the following competing hypotheses were formulated for direct testing:

> *Hypothesis 1A:* Both unfamiliar, instrumental sad music, and self-selected sad music—as well as sad autobiographical recall—will induce memory and judgment effects typically associated with experienced sadness, while neutral music will induce no effects.

> *Hypothesis 1B:* Only self-selected sad music and sad autobiographical recall will be able to induce memory and judgment effects, while unfamiliar, instrumental sad music, and neutral music will not induce memory or judgment effects.

In addition, it was hypothesized (Hypothesis 2) that trait empathy would contribute to the susceptibility to music-induced sadness—especially in the case of experimenter-selected, unfamiliar sad music.

Pilot Experiment

Stimulus Selection

The experimenter-selected, unfamiliar instrumental sad music had to meet the following criteria: 1. It conveys sadness in a clear manner, 2. The emotion conveyed does not change or vary during the course of the excerpt, 3. It is unfamiliar to most participants, and 4. The duration of the excerpt is at least 8 minutes (in order to induce a sad emotional state that would last for the duration of the indirect measures; for a review, see Västfjäll, 2002). After listening to several film soundtracks, an excerpt (duration 8 Minutes 35 seconds; starting at 2:25) from the piece *Discovery of the Camp* (*Band of Brothers* soundtrack; Kamen, 2001, track 17) was selected as the unfamiliar sad music. Furthermore, the first movement (*De l'aube à midi sur la mer*; duration 8 Minutes 35 seconds) of the orchestral work *La Mer* by Claude Debussy (used as neutral music previously by Martin & Metha, 1997) was chosen as the experimenter-selected neutral music. In addition, a piece of elating music (an 8-min excerpt from the piece *Band of Brothers Suite Two; Band of Brothers* soundtrack; Kamen, 2001, track 3) was chosen to bring the participants in the autobiographical recall condition to a more positive emotional state after the experiment.

Participants

The participants of the pilot experiment were 20 university students (from different faculties) aged 21–34 years (mean 25.3, $SD = 3.6$, 65% males).

Procedure

In order to confirm that the three excerpts conveyed the intended emotions, each excerpt was split into 14–15 shorter segments (approx. 35 seconds each), which were tested in a listening experiment along with two angry, two fearful, and two sad excerpts taken from a set of 110 film music excerpts (excerpts 001, 002, 011, 012, 031, and 032; Eerola & Vuoskoski, 2011). The participants were instructed to rate the emotions expressed by the excerpts using five discrete emotion scales (happiness, sadness, anger, fear, and tenderness) and two bipolar scales (valence and arousal). The five discrete emotions were selected on the bases that they are commonly expressed by music (see Juslin & Laukka, 2004) and cover all the quadrants of the two-dimensional valence-arousal space. All emotion ratings were done on scales from 1 to 7. In addition, the participants rated how familiar the excerpts sounded (1 = *unfamiliar*, 2 = *somewhat familiar*, and 3 = *very familiar*).

Results

The mean familiarity ratings for the sad, neutral, and elating excerpts were 1.14 ($SD = 0.36$), 1.06 ($SD = 0.24$), and 1.26 ($SD = 0.52$), respectively, confirming that the vast majority of participants found the excerpts unfamiliar. A repeated-measures ANOVA confirmed that the 14 segments of the experimenter-selected sad music expressed sadness more than any other emotion, $F(4, 76) = 75.4$, $p < .001$, η^2_G (Generalized Eta Squared; Bakeman, 2005) = .69. All post hoc comparisons of means (Tukey) between sadness and other emotions (happiness, tenderness, fear, and anger) were significant at the $p < .001$ level. The mean sadness rating for experimenter-selected sad music was 4.75 ($SD = 1.55$), while the mean sadness rating for a highly sad control stimulus (excerpt No. 031; Eerola & Vuoskoski, 2011) was 4.90 ($SD = 1.65$). For each of the 14 segments, sadness was the highest rated emotion, with the mean rating varying between 3.80 and 5.40. The mean valence and arousal ratings for the neutral excerpt were 4.01 ($SD = 1.27$) and 4.50 ($SD = 1.37$), respectively, confirming that the excerpt was neutral in terms of valence and neither high nor low in arousal (No. 4 signified the midpoint on the bipolar valence and arousal scales ranging from 1 to 7). Furthermore, a repeated-measures ANOVA confirmed that the elating piece (intended to bring the participants in Condition 4 to a more positive emotional state after the experiment) conveyed happiness more than any other emotion, $F(4, 76) = 93.98$, $p < .001$,

$\eta^2_G = .76$. All post hoc comparisons between happiness and other emotions were significant at the $p < .001$ level.

Discussion

The pilot experiment confirmed that the selected music excerpts conveyed the intended emotions. The experimenter-selected sad music conveyed sadness in an effective and consistent manner, and was unfamiliar to the vast majority of participants. Similarly, the neutral excerpt was rated as unfamiliar, neutral (in terms of valence), and neither high nor low in arousal. It was also confirmed that the elating excerpt conveyed happiness more than any other emotion. Thus, these excerpts were considered to be appropriate for the purposes of the actual experiment.

Experiment: Method

Participants

The participants were 120 Finnish university students from different faculties, aged 19–56 years (mean 23.7, $SD = 4.3$, 77.5% females). Ninety-seven percent of the participants were between 19 and 29 years of age. Fifty-five percent of the participants were nonmusicians, 34% had music as a hobby, and 11% were amateur or semiprofessional musicians. The participants were randomly assigned to four conditions: Participants in Condition 1 listened to unfamiliar, instrumental sad music chosen by the experimenters; participants in Condition 2 listened to neutral music chosen by the experimenters; participants in Condition 3 listened to self-selected sadness-inducing music; and participants in Condition 4 recalled an autobiographical event that had made them very sad and wrote about it (for a similar task, see Baker & Gutterfreund, 1993). There were 30 participants in every condition.

Stimuli

The participants in Conditions 1 and 2 listened to the unfamiliar sad and neutral music (respectively) described in the Pilot experiment. The participants in Condition 3 were instructed to bring approximately 8 minutes (1–2 pieces) of music that made them sad, and 8 minutes (1–2 pieces) of music that made them happy. The reasons for asking the participants to bring music that made them happy (in addition to the music that made them sad) were to conceal the true purpose of the experiment, and to use the happy music to induce a more positive emotional state after the actual experiment. Twenty-seven participants (90%) brought two sad pieces, while three participants brought one sad piece.

Measures

The participants' affective state in the beginning of the experiment was measured using the *Positive and Negative Affect Schedule* (PANAS; Watson, Clark, & Tellegen, 1988). The PANAS has 10 adjectives measuring positive affect, and 10 adjectives measuring negative affect. Prior to the experiment, the participants completed an empathy measure (*The Interpersonal Reactivity Index*; Davis, 1980). The IRI has 28 items that tap into four separate aspects of the global concept of empathy: *Fantasy, Perspective-taking, Empathic Concern*, and *Personal Distress*. The participants also filled in a short background questionnaire about their musical genre preferences, music listening habits, and musical expertise, as well as a personality measure (*The Big Five Inventory*; John & Srivastava, 1999) that was not included in the present analyses. All the measures used in the present experiment have previously been translated into Finnish.

The emotional states induced by the four different conditions were assessed using two indirect measures: a word recall task and a picture judgment task. In the word recall task, the participants had 2 minutes to write down as many adjectives as they remembered from the PANAS they completed in the beginning of the experiment (for a similar task, see, e.g., Hartig, Nyberg, Nilsson, & Gärling, 1999). Note that the participants were not instructed to memorize the PANAS adjectives. In the picture judgment task, the participants rated the emotions expressed by 25 composite pictures depicting prototypical and ambiguous facial expressions (created by Vanger, Hoenlinger, & Haken, 1998). The five prototypical facial expressions used in the present experiment expressed joy, sadness, anger, fear, and neutrality, and the 20 ambiguous expressions were computer-generated combinations of these five prototypical expressions (for details, see Vanger et al., 1998).

Procedure

The experiments were conducted individually for each participant. A special computer program was designed in MAX/MSP graphical programming environment (running on Mac OS X) to run the experiment and to collect data. In order to minimize the effect of demand characteristics, the participants were told that the purpose of the study was to investigate the effect of music listening on cognitive processing, namely memory and perception. They were not informed about the role of affect in these tasks. Participants in Condition 4 were told that they were randomly assigned to a control condition, where they would not listen to music before doing the memory and perception tasks. They were told that the effects of music listening would be compared to the control group, and that they would do the music listening task after the tasks measuring cognitive processing.

In the beginning of the experiment, the participants rated their current affective state using the 20 adjectives of the PANAS (one adjective at a time). The order of the adjectives was balanced across participants. The participants were told that the purpose of the affect measure was to control for a possible fatigue or boredom effect during the experiment. Next, participants in Conditions 1 and 2 listened to the experimenter-selected sad or neutral music, and participants in Condition 3 listened to their self-selected sadness-inducing music. They were instructed to concentrate on listening to the music, and to close their eyes if it helped them to concentrate. The duration of the music-listening part was approximately 8 minutes. Participants listened to the music pieces through studio-quality headphones, and were able to adjust the sound volume according to their own preferences.

While participants in Conditions 1, 2, and 3 listened to music, the participants in Condition 4 completed an autobiographical memory task intended to induce a sad emotional state. They received the following instructions:

> The next part is about memory and feelings. Your task is to think back to an event in your life that made you very sad. Try to remember in

> detail what happened and how you felt, and write a short description of the events in the text box below. The most important part of the task is to recall what happened in as much detail as possible. You will have 8 minutes to complete the task, after which the program will automatically move to the next part.

After the music listening task (or the autobiographical memory task), all participants completed the word recall task described in the Measures section. In order to minimize any possible negative effects this task might have on the participants' emotional states (in the case they found the task difficult; see, e.g., Hartig et al., 1999), the participants received the following instructions:

> The next part is about memory. Your task is to write down as many adjectives as you remember from the *Your current mood state* questionnaire (which you completed in the beginning of this experiment) in the text box that will appear below. You will have 2 minutes to complete this task (the time will start when you press the *OK* button). Do not start thinking about the words before pressing the button. This task does not measure intelligence or ability, and we do not expect anyone to remember all adjectives (or even close). We just want to find out how many of the adjectives you happen to remember in 2 minutes.

After 2 minutes had passed (during which the participants wrote down the adjectives they recalled), the computer program moved automatically to the picture judgment task. The 25 facial pictures were displayed in a different random order for each participant. The participants were instructed to rate the emotions each facial expression was expressing in their opinion using five rating scales (anger, fear, happiness, sadness, and neutral) ranging from 1 (*not at all angry*) to 7 (*very angry*). After the picture judgment task, the participants completed the PANAS questionnaire for the second time. Finally, participants in Conditions 1, 2, and 3 answered a few questions about the music listening task. They had to rate (on a scale from 1 to 7) how pleasant they found the music listening task (1 = *very unpleasant*, 7 = *very pleasant*), and how much they liked the music piece(s) they listened to (1 = *not at all*, 7 = *very much*). They were also asked to describe (by writing into a text box) what kinds of thoughts or impressions went through their minds during the music listening. Similarly, participants in Condition 4 were asked to rate how pleasant they found the autobiographical memory task. Participants in Conditions 1 and 2 finished the experiment after these final questions, but participants in Conditions 3 and 4 listened to happy or elating music for approximately 8 minutes before debriefing in order to ensure that they would be in a more positive emotional state by the end of the experiment. Participants in Condition 3 listened to their self-selected, happiness-inducing music, while participants in Condition 4 listened to the experimenter-selected elating music. After the experiment, all participants were fully debriefed and given a free movie ticket (value 7–14 €) in return for their participation.

Results

Memory Effects

The words were coded as correctly recalled if the root meaning of the word was correct. For example the words *kärttyisä* and *kärttyinen* (both mean *irritable*) were regarded as equivalent, as were the words *pelokas* (*fearful*) and *peloissaan* (*afraid*). The mean numbers of correctly recalled positive and negative words (for each condition) are displayed in Figure 1. In order to construct an aggregate measure combining the memory for both positive and negative words (as the number of words remembered varied considerably between participants), the number of correctly recalled negative words was deducted from the number of correctly recalled positive words. As it was expected that the differences between the neutral and sad conditions would be subtle (in comparison to previously reported differences between happy and sad affect inductions), two planned comparisons of means were carried out to test the competing hypotheses 1A [+1 −3 + 1 +1] and 1B [−1 −1 + 1 +1]. Hypothesis 1A predicted that participants in Conditions 1 (unfamiliar sad music), 3 (self-selected sad music), and 4 (sad recall) would display an affect-incongruent memory bias (i.e., more positive words remembered in relation to negative words), whereas participants in Condition 2 (neutral music) would not display a memory bias. In comparison, Hypothesis 1B predicted that only participants in Conditions 3 and 4 would display an affect-incongruent memory bias. The planned comparisons revealed that participants in Conditions 3 and 4 recalled more positive words in relation to negative words than participants in Conditions 1 and 2, giving support to Hypothesis 1B; $F(1, 118) = 7.92$, $p < .01$, $\eta^2 = .06$. The analysis concerning Hypothesis 1A did not reach statistical significance.

The recalled positive and negative words were further investigated within conditions using two-tailed, paired *t* tests. In Conditions 1 and 2, there was no difference between the number of correctly recalled positive and negative words; $t(29) = 0.41$, *ns*, and $t(29) = 0.32$, *ns*, respectively. In Condition 3, the difference between positive and negative words was not quite significant; $t(29) = 1.81$, $p = .080$, while in Condition 4, the difference was clearly significant; $t(29) = 4.80$, $p < .001$. The mean numbers of correctly recalled positive and negative words (in each condition) are illustrated in Figure 1.

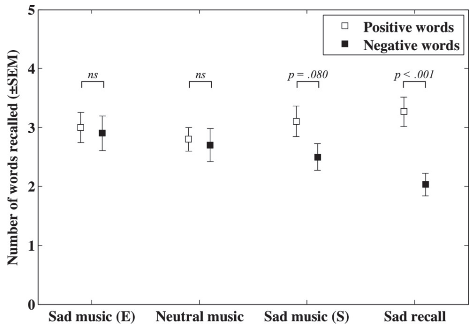

Figure 1. The mean number (± standard error of the mean) of positive and negative adjectives recalled by the participants in the different conditions (E = experimenter-selected sad music, S = self-selected sad music). The within-condition differences between the numbers of recalled positive and negative words were calculated using paired, 2-tailed *t* tests.

Judgment Effects

To eliminate the effect of possible individual differences in scale use, the raw emotion ratings for the facial expression pictures were standardized within subjects using individual *z*-score transformations. The *z*-scores were calculated using all emotion ratings of each participant. According to the affect-congruency theory (e.g., Bower, 1981), people experiencing a sad emotional state should give lower happiness ratings and higher sadness ratings to emotional stimuli. To investigate whether the mean happiness ratings (calculated from each participant's happiness ratings for all facial expressions) differed between certain conditions, planned comparisons were carried out to test hypotheses 1A [−1 + 3 −1 −1] and 1B [+1 + 1 −1 −1]. The results again supported Hypothesis 1B, $F(1, 118) = 6.52$, $p < .05$, $\eta^2 = .05$, as the analysis regarding Hypothesis 1A did not quite reach statistical significance ($p = .054$). The analyses confirmed that participants in Conditions 3 (self-selected sad music) and 4 (sad recall) gave lower happiness ratings to facial expressions than participants in Conditions 1 (unfamiliar sad music) and 2 (neutral music), thus displaying an affect-congruent judgment bias. Similar analyses were also conducted for mean sadness ratings. Both analyses failed to reach statistical significance, but the trend favored Hypothesis 1A [+1 −3 + 1 +1]: $F(1, 118) = 2.88$, $p = .092$.

Mood Prior to the Experiment

In order to confirm that the memory and judgment biases reflected the hypothesized changes in the participants' emotional states, 1-way ANOVAs were carried out to analyze the PANAS ratings collected in the beginning of the experiment. There was no main effect of condition in the PANAS ratings, confirming that there were no existing mood differences between the groups prior to the music listening or autobiographical recall. $F(3, 116) = 0.23$, *ns* for positive affect, and $F(3, 116) = 0.25$, *ns* for negative affect.

Individual Differences

To investigate Hypothesis 2, according to which highly empathic people may be more susceptible than others to emotional states induced by unfamiliar music, we had a closer look at the mean sadness ratings for facial expressions—the only variable suggesting a trend toward Hypothesis 1A. As trait empathy was hypothesized to play a key role in the process, we proceeded by investigating whether trait empathy and/or its subscales were associated with affect-congruent biases in the emotion ratings. Table 1 displays the correlations between global Empathy (and its subscales) and the participants' mean sadness ratings. Global Empathy and the Empathy subscale *Empathic Concern* correlated significantly with the mean sadness ratings in Condition 1 ($r = .63$, $p < .001$; $r = .48$, $p < .01$), and the Empathy subscale *Fantasy* correlated with mean sadness ratings both in Condition 1 ($r = .54$, $p < .01$) and Condition 3 ($r = .49$, $p < .01$). There were no statistically significant correlations in the other two conditions. These results suggest that empathy is associated with the susceptibility to musically induced emotional states, as trait empathy was connected to affect-congruent judgment biases only in the conditions where sad music—experimenter-chosen sad music in particular—was used to induce an emotional state.

Table 1
Correlations Between Empathy (and its Subscales) and the Participants' Mean Sadness Ratings for Facial Pictures (Grouped by Condition)

	Mean sadness ratings for facial pictures			
	Sad music (E)	Neutral music	Sad music (S)	Sad recall
Empathy (global)	.63***	−.08	.34	.25
Fantasy	.54**	−.21	.49**	.09
Empathic concern	.48**	.25	.31	.25
Perspective-taking	.27	−.12	−.21	.26
Empathic distress	.07	−.01	.13	.00

Note. E = Experimenter-selected sad music; S = Self-selected sad music.
** $p < .01$. *** $p < .001$.

This finding is further illustrated by Figure 2, which displays the combined happiness and sadness ratings of participants scoring high and low (median split) in global Empathy. Affect models typically characterize happiness and sadness as diametric opposites (see, e.g., Russell, 1980; Watson & Tellegen, 1985). As there were an equal number of prototypical and ambiguous (mixed) facial pictures expressing sadness and happiness (and as all emotion ratings were standardized within participants), the participants' mean sadness ratings were deducted from their happiness ratings in order to investigate a general judgment bias on the sad–happy continuum. Thus, in Figure 2, zero means no judgment bias, positive values signify a judgment bias toward happiness, and negative values signify a judgment bias toward sadness. In order to test for differences between high-empathy and low-empathy participants (median split) within conditions, two-tailed *t* tests were used to analyze the individual judgment biases on the sad–happy continuum. In Condition 1 (unfamiliar sad music), the difference between high-empathy and low-empathy participants was statistically significant, $t(28) = -2.29$, $p < .05$, indicating that the high-empathy participants were displaying a stronger judgment bias toward sadness. In comparison, there were no differences between high- and low-empathy participants in Conditions 2, 3, or 4; $t(28) = 0.94$, $t(28) = -0.23$, and $t(28) = 0.78$ (respectively), all *ps* = *ns*.

Next, planned comparisons investigating the combined happiness and sadness ratings were carried out separately for participants scoring high and low in global Empathy (median split). For the high-empathy participants, the results favored Hypothesis 1A [−1 + 3 −1 −1], $F(1, 57) = 6.68$, $p < .05$, $\eta^2 = .10$, while the results regarding the low-empathy participants gave support to Hypothesis 1B [+1 + 1 −1 −1], $F(1, 59) = 5.86$, $p < .05$, $\eta^2 = .09$. In other words, the high-empathy participants in Condition 1 (unfamiliar sad music) had a judgment bias toward sadness that was significantly different from Condition 2 (neutral music)—similarly to the participants in Conditions 3 and 4. In comparison, the low-empathy participants in Condition 1 did not differ from the neutral condition in terms of judgment biases.

As most of the participants were female (77.5%), we also investigated whether gender contributed to the emotional states induced by music or autobiographical recall. Two-way ANOVAs revealed no main effects of gender on the word recall task or the

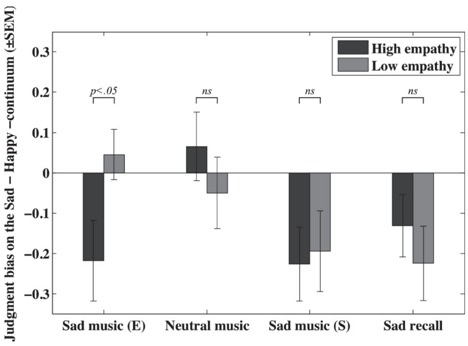

Figure 2. The mean judgment biases (± standard error of the mean) in the combined sadness and happiness ratings (for facial expressions) of participants scoring high and low in trait empathy (median split), grouped by condition (E = experimenter-selected sad music, S = self-selected sad music). Zero equals no judgment bias, positive values signify a judgment bias toward happiness, and negative values signify a judgment bias toward sadness. The within-condition differences between high- and low-empathy participants were calculated using 2-tailed *t* tests.

picture judgment task, and no interaction (condition × gender) effects. Regarding the personality traits associated with a susceptibility to musically induced emotional states, 1-way ANOVAs revealed main effects of gender in global Empathy, $F(1, 118) = 8.06$, $p < .01$, $\eta^2 = .06$, and its subscale Empathic concern, $F(1, 118) = 7.53$, $p < .01$, $\eta^2 = .06$. For females, the mean Empathy score was 99.98 ($SD = 8.47$), and for males 94.15 ($SD = 12.13$). However, there was no main effect of gender on the subscale Fantasy, $F(1, 118) = 3.65$, $p = .059$. These findings are in line with previous research that has reported gender-related differences in self-reported empathy, while physiological, gestural, and facial measures of empathy have revealed nonexistent gender differences (for a meta-analysis, see Eisenberg & Lennon, 1983).

Free Descriptions of Thoughts That Occurred During Music Listening

After completing the indirect (and direct) measures of emotional states, the participants were asked to describe what kinds of thoughts or impressions went through their minds while they were listening to the music. The free descriptions of participants in Conditions 1 and 3 were coded using classical content analysis (see, e.g., Ryan & Bernard, 2000), with the aim to construct classifying themes that would account for the broad, common constituents of the participants' thoughts and impressions. The emotion-induction mechanisms proposed by Juslin and Västfjäll (2008) were used as a framework for the coded themes, although other themes also emerged from the data. Each free response was coded according to the predominant theme. The data were first coded by one of the experimenters, and then verified by the other experimenter using the same criteria (Cohen's $\kappa = .77$). The few mismatching cases were discussed and adjusted accordingly. The found themes were: 1. *Sad imagery* (e.g., "The piece was quite melancholic and made me think of the ending of a sad movie. Maybe someone had died or gone away and left someone else missing him/her"), 2. *Sad memories* (e.g., "I thought a lot about my grandmother who passed away, and how I wouldn't want to lose anyone else"), 3. *Other imagery* (e.g., "The piece evoked impressions of nature; storm, water, wind, and swaying trees"), 4. *Unspecified memories* (e.g., "The pieces brought back memories from the time when I used to listen to these pieces a lot"), 5. *Sadness mentioned in another context* (e.g., "The piece sounded sad", or "I felt a little melancholic"), and 6. *Other* (e.g., " I felt sleepy", or "I thought about the artist's baby"). The distribution of the different themes in Conditions 1 and 3 is summarized in Table 2. One participant in Condition 3 did not provide any free descriptions, and has thus been omitted from the table.

As can be seen from Table 2, here were notable differences between the free descriptions of the participants in the two conditions: in Condition 1, seven participants (23%) reported thinking about sad imagery and six reported thinking about other imagery, whereas in Condition 3, the number of participants with the same themes were two and one. In contrast, 14 participants (47%) in Condition 3 thought about sad personal memories and four thought about unspecified personal memories, while in Condition 1, only one participant thought about sad memories and two thought about unspecified memories. In addition, one participant in Condition 1 and two participants in Condition 3 reported crying during the music listening. None of these three participants reported thinking about personal memories during the music listening.

Pleasantness of Music Listening and Autobiographical Recall

The mean pleasantness ratings for the music listening tasks and the autobiographical recall task were 5.7 (unfamiliar sad music), 5.2 (neutral music), 5.2 (self-selected sad music), and 3.6 (sad recall). The ratings were made on a scale from 1 (*very unpleasant*) to 7 (*very pleasant*). A 1-way ANOVA yielded a main effect of condition, $F(3, 116) = 13.88$, $p < .001$, $\eta^2 = .26$, and post hoc analysis (Tukey) revealed that the pleasantness ratings in Condition 4 (sad recall) differed significantly from all other conditions ($p < .001$). It is interesting to note that listening to the experimenter-selected sad music was found to be more pleasant than listening to the neutral music or self-selected sad music, although these differences were statistically nonsignificant.

Table 2
The Distribution of the Themes Found in the Free Descriptions (About Thoughts and Impressions That Occurred During Music Listening) of Participants Who Listened to Experimenter-Selected, Unfamiliar Sad Music (E), and Participants Who Listened to Self-Selected Sad Music (S)

	Sad music (E)	Sad music (S)
Sad imagery	7 (23%)	2 (7%)
Sad memories	1 (3%)	14 (47%)
Other imagery	6 (20%)	1 (3%)
Unspecified memories	2 (7%)	4 (13%)
Sadness mentioned (other)	7 (23%)	6 (20%)
Other	7 (23%)	2 (7%)

Liking Ratings for Music Pieces

Finally, we investigated the liking ratings given to the music pieces. The mean ratings were 5.3 (unfamiliar sad music), 4.6 (neutral music), and 6.4 (self-selected sad music). Neutral music was the least liked, while self-selected sad music was the most liked. A 1-way ANOVA yielded a main effect of condition, $F(2, 87) = 15.48$, $p < .001$, $\eta^2 = .26$, and post hoc analyses (Tukey) revealed that the familiar, self-selected sad music was liked significantly more than unfamiliar, experimenter-selected sad music ($p < .01$) or neutral music ($p < .001$).

Discussion

This study aimed to investigate whether sad music could induce genuine sadness in listeners. Two indirect measures of experienced affect—a word recall task and a picture judgment task—demonstrated that self-selected sadness-inducing music (Condition 3) could indeed induce memory and judgment effects that were significantly different from the neutral condition—despite the fact that the self-selected, familiar music was loved by the participants. However, experimenter-selected, unfamiliar sad music (Condition 1) managed to induce a sad emotional state only in empathic participants.

Participants in Conditions 3 (self-selected sad music) and 4 (autobiographical recall) displayed affect-incongruent biases in the word recall task. Although the associative network theory of affect (Bower, 1981) postulates that affective states should lead to affect-congruent memory effects, it has been demonstrated that affect-incongruent memory effects emerge when participants are unaware of the relevance of their moods and emotions to the experiment (Parrot & Sabini, 1990), or when the recalled material is only mildly pleasant or unpleasant (Rinck, Glowalla, & Schneider, 1992). Both specifications were met by the present experiment, as participants were not informed about the relevance of their emotional states to the experiment, and most of the PANAS adjectives in the word recall task were not strongly pleasant or unpleasant. The memory bias was somewhat stronger in Condition 4 (compared to Condition 3), which may result from differences in the two affect-induction tasks, as well as from the type of adjectives used for the word recall task. As the autobiographical recall task was experienced as significantly more unpleasant than the listening task (with self-selected sadness-inducing music), it is possible that the recalled pleasant and unpleasant adjectives reflected the difference in the pleasantness of the two tasks—in addition to the induced sad emotional state. This may also partly explain the lack of mood-incongruent memory effects in Condition 1, as listening to the unfamiliar sad music was found to be even more pleasant than listening to the neutral music or self-selected sad music.

The judgment task (where participants evaluated emotions expressed by facial pictures) revealed strong, affect-congruent judgment biases in Conditions 3 and 4. As this task measured specifically the judgment bias in perceived happiness and sadness, it is plausible that the task reflected more clearly the induced (sad) emotional states. The judgment bias in sadness ratings was also the only variable suggesting a trend toward Hypothesis A, according to which experimenter-selected, unfamiliar sad music (Condition 1) also would be able to induce genuine sadness in participants. However, closer examination revealed that the experimenter-selected sad music was able to successfully induce a sad emotional state only in participants scoring high in trait empathy. Highly empathic participants in Condition 1 displayed a judgment bias that was significantly different from the neutral condition, whereas participants scoring low in empathy did not display a judgment bias. These individual differences in the susceptibility to music-induced sadness have implications not only for the study of music and emotions, but also for studies aiming to affect the participants' emotions or moods through music listening. As the emotional responsiveness to unfamiliar music seems to be strongly associated with trait empathy, this limits the effect sizes and generalizability of findings in studies utilizing such stimuli.

As the vast majority of the participants in Condition 1 did not report thinking about personal memories during the music listening, the significant connection between empathy and sadness induced by unfamiliar sad music suggests that real sadness can be experienced through emotional contagion—a subcomponent of empathy as well as one of the emotion induction mechanisms suggested by Juslin and Västfjäll (2008). It may also be that unfamiliar, instrumental sad music is able to induce sadness through visual imagery (see Juslin & Västfjäll, 2008), as 23% of the participants in Condition 1 described thinking about sad imagery during the music listening.

In comparison, self-selected sad music was strongly associated with autobiographical memories, as 47% of the participants in Condition 3 reported thinking about sad memories, and 13% reported thinking about unspecified memories during the music listening. This suggests that the mechanism episodic memories (see Juslin & Västfjäll, 2008) plays an important role in sadness induced by music that has personal relevance. It is also worth noting that the content of lyrics may have contributed to the induced emotional states, as 91.5% of the self-selected sad music contained lyrics. This possibility is rendered probable by the findings of previous studies (e.g., Ali & Peynircioylu, 2006; Brattico et al., 2011) that suggest lyrics may be important for music-induced sadness. However, there may be other mechanisms as well—such as emotional contagion—that contribute to sadness induced by personally relevant, familiar music, since Fantasy—the tendency to imaginatively transpose oneself into the feelings and actions of fictitious characters (Davis, 1980) —was related to higher mean sadness ratings also in Condition 3.

Global Empathy and Fantasy have previously been associated with the enjoyment of sad music (Vuoskoski et al., in press; Garrido & Schubert, 2011). As these two personality attributes were related to the susceptibility to music-induced sadness in the present study, it could be speculated that the intensity of music-induced sadness and the enjoyment of sad music are connected. If this is indeed the case, it opens new, intriguing directions for future studies seeking to explain the mechanisms behind the pleasure generated by sad music (or music-induced sadness; cf., Huron, 2011). These findings may also have implications for music therapy applications, as music therapy is effectively used in the treatment of depression (see, e.g., Erkkilä et al., 2011), for example.

In summary, this study demonstrated that sad music could indeed induce sadness-related effects on memory and judgment. However, this effect depends—to some extent—on the music's relevance to the listener, as well as on the personality attributes of the listener. Most noteworthy is the fact that this study demonstrated that genuine sadness could be induced by unfamiliar sad music, without any apparent autobiographical content—challenging the longstanding claims of the musical "cognitivists" (e.g., Kivy, 1989, 1990). Trait empathy contributed to the susceptibility to sadness induced by unfamiliar, instrumental music, while autobiographical memories contributed to sadness induced by self-selected music. Listening to sadness-inducing music was found to be significantly more pleasant than the recollection of sad autobiographical memories, suggesting that while sad music is able to induce similar effects on emotion-related memory and judgment as autobiographically induced sadness, the subjective experience of music-induced sadness is intrinsically more pleasurable.

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