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Kari Kallinen

Towards a Comprehensive Theory of Musical Emotions

A Multidimensional Research Approach and Some Empirical Findings

JYVÄSKYLÄN YLIOPISTO

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ABSTRACT

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The present work summarizes the results of a series of experiments that focused on the emotional effects of music *per se*, in particular background music on other activities such as reading or listening to news messages, as well as on the potential moderating influence of various individual difference variables on the relationship of music with emotional responses. We defined emotions as processes that are influenced by various interactive components, such as musical attributes (e.g., tempo, harmony, musical genre), individual attributes (e.g., musical preferences, personality), and contextual attributes (e.g., music in connection with everyday activities or multimodal information). In order to control the various factors related to musical emotions, we proposed a multidimensional research approach, which consists of (a) measuring subjective responses, psychophysiological responses, and various traits, and (b) examining the relationships between the musical, individual, and contextual attributes that may influence emotions. The results suggest, for example, that music is a multidimensional phenomenon, and that musical emotions are heterogeneous and hierarchical. The results also suggest that music often arouses emotions that are very similar to the ones it is evaluated as being expressive of. We also found that the interaction between personality and musical stimuli can usually be explained by similarity-attraction. That is, people are attracted to persons or media stimuli similar to their own personality. The results also suggest that the interaction between (background) music and some other stimuli (e.g., reading) can usually be explained by mood congruency (i.e., individuals preferentially process emotional stimuli that are emotionally congruent with each other and/or with their current mood state). In sum, the multidimensional research approach seems to produce many interesting results that are presumably more precise than those yielded by previous research on emotional effects of music. However, it should be acknowledged that more research is needed to understand the functions of different components of musical emotions.

Keywords: Music, emotion, psychology, personality, psychophysiological responses

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PREFACE

This dissertation is a collection of papers that focused on different aspects of music-related emotions. Most of the work was done in the Knowledge Media Laboratory, Center for Knowledge and Innovation Research (CKIR), in Helsinki School of Economics. A number of people have contributed to my work, most notable my colleagues in CKIR. I am especially grateful to Dr. Niklas Ravaja, the other supervisor of the thesis and the co-author of most of the papers, for the tuition and support for the work. I am also grateful to Dr. Jari Laarni for many fruitful discussions and comments on my work. I would also like to thank Dr. Timo Saari for hiring me at the lab; without the knowledge media lab facilitates the multidimensional approach used in the present study would not have been possible - thank you for your vision.

The writing of this summary was supported by a grant from University of Jyväskylä. Many thanks especially for Professor Petri Toiviainen, the other supervisor of the thesis. I am also grateful for the inspectors of the thesis, Professor Marcel Zentner and Professor Christina Krause, for the comments and suggestions to improve the work. Finally, I would like to express my gratitude to my wife Merja for her support in the last stages of this project.

Helsinki, March 15th 2006
Kari Kallinen

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following publications, which will be referred to in the text by their Roman numerals (I-VII):

I Kallinen, K. (2005). Emotional ratings of music excerpts in the western art music repertoire and their self-organisation in the kohonen neural network. *Psychology of Music, 33 (4)*, 373-393.

II Kallinen, K. & Ravaja, N. (in Press). *Emotion perceived and emotion felt: same and different*. Musicae Scientiae.

III Kallinen, K. & Ravaja, N. (2003). Emotion-related responses to audio news with rising versus falling background tone sequences. *Musicae Scientiae Special Issue, 2003*, 85-110.

IV Kallinen, K. (2002). Reading news from a pocket computer in a distracting environment: effects of the tempo of background music. *Computers in Human Behavior, 18(5)*, 537-551.

V Kallinen, K. & Ravaja, N. (2004). The role of personality in emotional responses to music: verbal, electrocortical, and cardiovascular measures. *Journal of New Music Research, 33(4)*, 399-409.

VI Ravaja, N., & Kallinen, K. (2004). Emotional effects of startling background music during reading news reports: The moderating influence of dispositional BIS and BAS sensitivities. *Scandinavian Journal of Psychology, 45(3)*, 231-238.

VII Kallinen, K. & Ravaja, N. (2004). Emotion-related effects of speech rate and rising vs. falling background music melody during audio news: the moderating influence of personality. *Personality and Individual Differences, 37(2)*, 275-288.

AUTHOR'S CONTRIBUTION TO PUBLICATIONS

Two of the papers (studies I and IV) on which this thesis is based on are by the author. Five of the original publications (II, III, V, VI, and VII) are joint articles. The author designed the study, recruited participants, made the stimuli, organized the experimental settings, collected and analyzed the data (including psychophysiological measurements), and mainly wrote the article in regard to the publication numbers II, III, V, and VII. Dr. Niklas Ravaja helped the author with the design and data analysis, and commented and corrected the manuscripts (including some, and occasionally substantial, re-wording of the text). In connection with the publication number VI, Dr. Ravaja designed the study, analysed the data and mainly wrote the article. The author recruited the participants for the study, made the stimuli, organized the experimental setting, performed the experiment (including the psychophysiological data collection), helped with the analysis and organization of the (raw) data, and commented the manuscript (including some rewording).

CONTENTS

1 INTRODUCTION

One of the most powerful motifs of musical activities is the ability of music to express and induce emotions. Both scientific research and common experiences suggest that a great variety of emotions are attached to music: sometimes music may lead us to deep sorrow or overwhelming joy, while at other times we can be totally unmoved by it. Although much is known about music practices and techniques, the relationship between music and emotion is still a field where much is unknown (see e.g., Juslin and Zentner, 2002; Iwanaga and Moroki, 1999; Peretz, 2001). And yet, it is the power of music to express and induce emotions that is one of the most significant reasons for musical activities (see e.g., Sloboda et al., 2001).

The present work summarizes the results of a series of experiments on the emotional effects of music per se, as well as of background music on other activities, such as reading or listening to news messages.

1.1 Theories of Emotion

Even though laymen seem to share a common conception of the emotions, among scientists, there appears to be a considerable controversy as to the definition of emotion. For example, there has been disagreement about the origin of emotions (mind or body) and the number and quality of emotions (i.e., are there some emotions that are more fundamental than others). The most general definition is that emotions are biologically based action dispositions that have an important role in the determination of behaviour (e.g., Lang, 1995). Most theorists endorse the view that emotions comprise three components: the subjective experience (e.g., feeling angry), the expressive component (e.g., severe frown), and the physiological component (e.g., sympathetic nervous system activation); others add motivational state or action tendency and/or cognitive processing (see Scherer, 1993). In general, negative emotions include behavioural components of withdrawal and positive emotions a tendency to approach the source of the stimulus (Frijda, 1986). Lazarus (1993) has emphasized the role of appraisal processes in the elicitation of emotions. In contrast, Zajonc (1980) has suggested that affective reactions can be elicited with minimal stimulus input and virtually no cognitive processing, and that they can be evoked earlier than cognitive responses. However, the role of cognitive processing in the context of music-elicited emotions is not clear, though more comprehensive view would suggest that typically, a full emotional experience includes both the interpreting mind and the feeling body.

Some theorists argue that basic distinct emotions, such as anger, fear, sadness, happiness, disgust, and surprise, are present from birth, have distinct adaptive value, and differ in important aspects, such as appraisal, antecedent events, behavioural response, and physiology (e.g., Ekman, 1992). According to a competing view, emotions are fundamentally similar in most respects, differing only in terms of one or more dimensions. Proponents of the dimensional view have suggested that a large amount of variation in emotions can be located in a two-dimensional space, with coordinates of (a) valence and arousal (e.g., Lang, 1995; Larsen and Diener, 1992), or (b) positive activation (PA) and negative activation (NA; Watson and Tellegen, 1985). The valence dimension refers to the hedonic quality of an affective experience and ranges from negative to positive. The arousal dimension refers to the perception of arousal associated with such an experience. In the present study, music and measures were based on both the "basic emotion" theory (study I, II), as well as the dimensional view of emotions (valence and arousal; studies II-VII).

1.2 Emotions and Music

1.2.1 Sources of Musical Emotions

The linkage between music and subjective emotional experiences is not clear-cut. For example, Sloboda and Juslin (2001) have proposed extrinsic and intrinsic sources of emotion in music. Extrinsic emotional meaning arises from the associations between music and an outside experience (e.g., "darling they are playing our tune") or object (e.g., characteristics of speech), whereas intrinsic emotional meaning is based on the perceptual or learned characteristics of music per se (e.g., violation of expectancy; see e.g., Meyer, 1956).

Semiotic theory describes another similar way the emotional meanings operate in music. According to semiotic theory, sounds can indicate meaning (i.e., act as a sign; see Saussure, 1916a and 1916b) as an index, icon or symbol. Indexical meaning arises from the associative relation of any two signs that are based in co-occurrences and thus have become strongly bound (see Dowling & Harwood, 1986; Turino, 1999). For example, the dominant chord (V7) leading to the tonic chord (I) may index musical closure in European societies because it is a very common signifier of progression at the end of a musical piece. The term icon refers to the sign related to its object through some type of (structural) resemblance between them. For example, a rising melodic line may create a heightened response in a listener because it sounds similar to the human voice with a rise in pitch, as the speaker becomes excited. Symbols derive their meaning not only from relationships between perceptual patterns and sensory icons but also from the relationships and hierarchy of other symbols, such as violations of expectancy (Dowling & Harwood, 1996; Meyer, 1956). Whether indices, icons, and symbols really capture the nature of musical emotions is not clear, however, because there are few studies that have examined other than the "iconic" level of meaning (with the exception of Kallinen, in revision).

1.2.2 Objective and Subjective Emotional Meaning of Music

It has been suggested that, although reactions to music are broad, people can be quite consistent in their overall judgments of the emotional quality of a piece of music (Hevner, 1936; Sloboda, 1991). However, as pointed out by Gabrielsson (2002) in his recent review, the distinction and relationships between the perceived emotional quality of the music (emotion perceived) and the emotion music arouses in the listener (emotion felt) are not well established because (a) the distinction has not always been made and (b) there is a scarcity of studies that deal with both the "objective" and "subjective" aspects of music-elicited emotion. Music per se may have a recognizable character (e.g., emotional meaning) that may differ from the listener's subjective meaning. The individual emotional meaning, in turn, is not stable but may be different in different contexts and at different times. Lazarus and Smith (1988, p. 286) have defined the relationship and reason for differential individual responses to the same musical stimuli: "Music can give rise to very different kinds of emotions because people are biologically and mentally different and because they all have their unique emotional situations' appraisal history". Thus, we have formulated a more comprehensive view on musical emotions that sees music as an interaction of musical, individual and contextual factors.

1.3 Towards a Comprehensive Theory of Musical Emotion

All kinds of musical meanings have one thing in common–whether extrinsically or intrinsically based, musical emotional meaning always emerges from the interaction of a listener and a (real or imaged) sound object in some context. Many of the problems and discrepant findings concerning emotions and music might be due to (1) the fact that experiments have dealt with only one aspect of musical emotions (e.g., perceived emotional quality) and generalized the findings to all emotions in music, (2) conceptual confusion, such that the terms affect, mood, emotion, and feeling have been used interchangeable, even though they might describe or focus mainly on different components of the emotions, (3) treating subjects as a homogeneous group of listeners (i.e., neglecting the fact that musical meaning is not absolute, but moderated by individual differences), and (4) treating musical meaning as free of context (i.e., neglecting the effect of context).

As illustrated in figure 1, a comprehensive view on musical emotions would suggest that emotions consist of many components (e.g., cognitive processes, physiological arousal, expressions, and actions) that are connected to other forms of meaning (e.g., intellectual and contextual meaning). For conceptual clarification the term "emotion" could be used for the emotional experience consisting of both the perceived emotional quality (i.e., the more cognitive part of emotion) and the emotion felt (i.e., including the physiological responses), whereas the term affect, for example, could be describing an emotion related state with an emphasis on the physiological component of emotion.

The emotional experience consists of and is moderated by the characteristics of the sound object, the individual, and the social (or multimedia or other) context. Listeners may perceive an emotional quality in music (cognitive evaluation), which may lead (but not necessarily) to felt emotion (with physiological responses). Music may arouse an emotional experience in listeners top-down (from cognition), bottom-up (from physiological effects), or center-out (i.e., cognition and arousal in parallel) both intrinsically (by the characteristics of structure and expression) and extrinsically (by referring to previous memories of distinct music pieces, structures, and expressions). However, emotion is a process on a time continuum where the interaction of the various attributes of emotions and emotional experience takes place continuously. In some (primitive) cases music may elicit affective reactions with minimal or no cognitive effort (a sudden loud sound, for example). However, in most cases the prerequisites for emotional experience include at least minimal cognitive processing of the sound stimulus, given that the emotional meaning in music is not directly linked to survival and well being as in real life emotions, but more to meaning based on learning through exposure to music (Dowling & Harwood, 1998). Finally, an emotional experience may involve or lead to expressions and actions, such as facial expressions (e.g., disgust) and withdrawal of the object (e.g., negative emotion), which, in turn, may also contribute to the process of emotional experience.

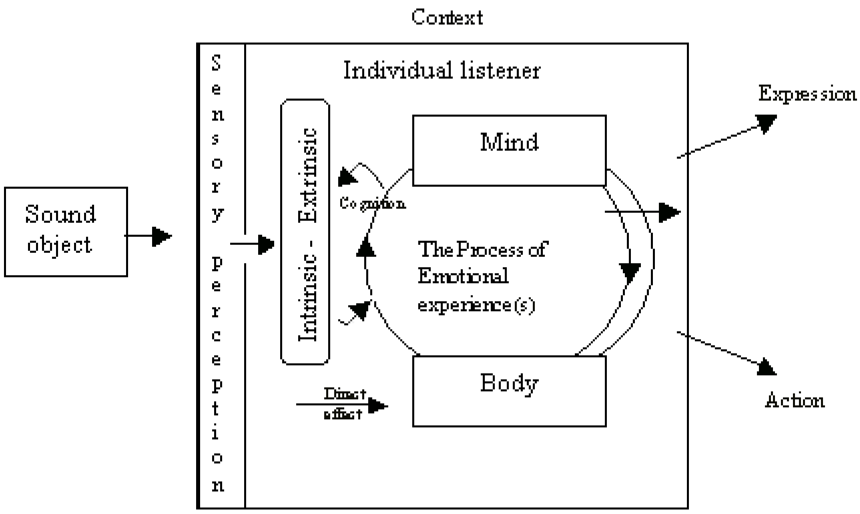

FIGURE 1 The process of emotional experience.

We shall next discuss the different components in more detail and present some relevant previous studies.

1.3.1 Music

The music itself is the most researched attribute in musical emotions. Studies on the emotional responses to music have typically used adjective checklists in assessing emotional responses. For example, Hevner (1936) found a significant correlation between the structural properties of music and adjectives that were chosen to describe the emotional quality of music. That is, the structural properties of music were linked to distinct emotions. More recently, Gabrielsson and Juslin (1996) and Juslin (1998) have studied the production and communication of emotional gestures through music. Musicians were able to express and communicate the basic emotions (i.e., happiness, sadness, anger, fear, tenderness, and solemnity) by manipulating the characteristics of the music, such as tempo, dynamics, timing, and spectrum.

A variety of self-report (e.g., emotional evaluations, emotional experiences), brain (e.g., electroencephalogram [EEG], event-related potentials [ERPs]), and other physiological measures (e.g., heart rate [HR], skin conductance [SC], respiration rate, blood pressure, blood volume, muscular tension, motor and postural responses) have been used, but the findings concerning the effects of music on these measures are inconclusive (see e.g., Iwanaga & Moroki, 1999; Perez, 2001). Musical compositions have been shown to prompt similar ratings of basic emotions (i.e., happiness, sadness, fear, and anger) across different listeners (e.g., Hevner, 1936; Cupchik, Rickert, & Mendelssohn, 1982; Tervogt & Van Grinsven, 1991). It has also been found that music may have a positive effect on mood (Scheel and Westefield, 1999) and reduce anxiety, stress, and negative feelings (Davis & Thaut, 1989; Hanser, 1990; Lai, 1999). Different types of music have also been shown to induce varying emotion-related psychophysiological responses (e.g., Iwanaga & Moroki, 1999;

Savan, 1999; Lai, 1999; Witvliet & Vrana, 1996). Field et al. (1998) found that cortisol levels decreased and relative right frontal activation was significantly attenuated during and after music listening even though observed and self-reported mood did not change. Davis and Thaut (1989) found that music aroused and increased autonomic and muscular activity. In regard to cardiac activity, Saperston (1995) found no effects, whereas Iwanaga et al. (1996) found that sedative music decreased HR, and Iwanaga and Maroki (1999) found that excitative music increased HR. Gerra et al. (1998) showed, in turn, that HR and systolic blood pressure increased during techno music. They also found that emotional and neuroendocrine responses during techno music were associated with Cloninger's temperament dimensions (i.e., Novelty Seeking and Harm Avoidance); that is, these temperament dimensions moderated the relation of music with emotional responses.

The psychophysiological responses elicited by music varying in emotional tone have also been investigated. Krumhansl (1997) found that sad excerpts produced the largest changes in HR, blood pressure, electrodermal activity (EDA), and digital temperature; fear-related excerpts produced the largest changes in pulse transit time (PTT) and finger pulse amplitude; happy excerpts produced the largest changes in respiration measures.

Interest in human EEG has focused mainly on the 0-30-Hz range (Pivik et al., 1993). Most of the studies have examined the reduction of alpha power (8-13 Hz), which has been used as an index of relaxed wakefulness, but also the theta range (5-7 Hz) that is common during a state of drowsiness, and beta range (13-30 Hz) characterized as an index of alert attentiveness have been investigated (Davidson, Jackson, & Larsen, 2000). In regard to the neural correlates of emotions, a considerable body of research has found a relationship between emotions and frontal cortical activity (e.g., Davidson, Ekman, Saron, Senulis, & Friesen, 1990; Ekman, Davidson & Friesen, 1990; Jones & Fox, 1992). Some studies suggest that left and right frontal alpha activation is related to the experience of positive and negative emotions, respectively ("valence hypothesis"; e.g., Ahern & Swartz, 1979; Davidson, 1992), whereas other studies suggest that the right hemisphere processes both positive and negative information ("right hemisphere hypothesis"; e.g., Safer, 1981; Carmon & Nachson, 1973; Bowers, Bauer, & Heilman, 1993). Smith and Trainor (2001) found support for the frontal lateralization theory of emotions in the context of music: subjects exhibited more relative left frontal alpha activation during joyous and happy musical excerpts, and more relative right frontal activation during fearful and sad excerpts. In addition, they proposed that the increase in overall frontal activity distinguished the intensity of emotions.

However, the evidence for the valence view of cerebral asymmetry is not conclusive (Perez, 2001). Bryden, Ley, and Sugarman (1982) found support for the right hemisphere hypothesis. That is, the accuracy of judging the emotional tone of stimuli was better when stimuli were presented to the left ear than when presented to the right ear. However, because there are only a few studies on emotion-related EEG responses elicited by music, there should be more research to confirm the findings in a larger body of music.

In the present study we used both self-report (i.e., the more cognitive part of emotion) and psychophysiological measures that were (a) EDA indexing sympathetic nervous system activity and emotional arousal; (b) heart rate that decelerates (i.e., longer interbeat intervals [IBIs]) when attention is paid to an external stimulus or information is taken in (Berntson, Cacioppo, & Fieldstone, 1996); (c) PTT that is determined by α-sympathetic stimulation, among other factors (McDonald, 1974), and has been shown to shorten during sensory intake tasks (i.e., attention to an external stimulus; Ravaja, 2004), (d) respiratory sinus arrhythmia (RSA) indexing attention, and (e) EEG to index positive and negative valence and general level of arousal.

1.3.2 The Individual Listener

As noted earlier, there may be many important individual differences (i.e., moderator variables such as personality) that affect the nature and magnitude of emotional responses to music. The main focus in the present studies was on the effects of personality. Personality can be defined as a pattern of feelings, thoughts, and activities that distinguishes one person from another. In connection with personality and media stimuli, it has been found, for example, that extroverts and high sensation seekers show a tendency to seek stimulation in order to raise their arousal to hedonic optimal levels (see Matthews and Gilliland, 1999; Zuckerman, 1990). It has also been suggested that individuals preferentially process emotional stimuli that are congruent in emotional tone with their stable personality traits (Rusting, 1988) and are attracted to persons or media stimuli similar to their own personality (i.e., similarity-attraction principle; e.g., Nass and Lee, 2001). However, only a few studies have examined personality issues in connection with music (e.g., Hansen and Hansen, 1991; Dollinger, 1993; Rentfrow and Gosling, 2003). For example, Dollinger (1993) found that extraversion and excitement seeking were related to a preference for music with high-arousal properties. It could be expected, for example, that subjects characterized as extroverted would engage in music more easily and experience stronger felt emotions than subjects characterized as introvert or prone to anxiety.

We used dispositional behavioural inhibition system (BIS) and behavioural activation system (BAS) sensitivities as moderator variables because, according to Gray (1982), these two primary brain motivational systems underlie behaviour and affect. The BIS regulates aversive motivation and controls the experience of anxiety in response to anxiety-relevant cues. It is sensitive to signals of punishment, nonreward, and novelty, and is associated with increased arousal and attention. The BAS regulates appetitive motivation, and is sensitive to signals of reward, nonpunishment, and escape from punishment (Pickering & Gray, 1999). Gray holds that greater BAS sensitivity is reflected in greater proneness to engage in goal-directed efforts and to experience positive feelings when the individual is exposed to cues of impending reward. It is also of note that EDA and HR are strongly associated with BIS and BAS activity, respectively (Fowles, 1980).

Another psychobiological model of personality is that presented by Zuckerman and co-workers (Zuckerman et al., 1993): the Alternative Five. This model of personality comprises five dimensions: Impulsive Sensation Seeking (ImpSS), Neuroticism-Anxiety (N-Anx), Aggression-Hostility (Agg-Host), Activity (Act), and Sociability (Sy). These psychobiological models of personality (or temperament) were considered to be relevant in the present connection, given that we were interested in subjects' psychophysiological responses, among other things. Both models were used to get a more comprehensive assessment of potentially significant personality dimensions.

1.3.3 Context

The listening context is probably the least investigated of the attributes that influence on emotions elicited by music. And clearly, music may have very different effects on listeners when it is listened to in a concert versus as background music in a supermarket, for example. Sloboda et al. (2001) found that people use music to accompany a wide range of everyday activities, such as cleaning a house or driving a car. However, there exist a scarcity of studies on how the different context moderates the experience. We recently found that listening to background music during reading entertainment news in a pocket computer significantly moderated the reading and pocket computer user experience as compared to reading news without background music (kallinen, unpublished data). However, when we compared the user responses in a cafeteria to the user experiences in a quiet office-room we found that the responses were moderated by the listening/user context. For example, the user's attention was focused more on the music in the quiet office, whereas it was focused more on reading in the cafeteria environment.

Context may also refer other factors than a physical location. In connection with multimedia, the context for music listening may be another stimuli or a task that is done during listening to music. As noted above background music may accompany a wide range of activities or different multimodal content, therefore modifying the emotional or other responses. For example, music has been shown to influence the performance of cognitive tasks. Rauscher, Shaw, and Ky (1993, 1995) found significant enhancement on spatial-temporal tasks after listening to a Mozart piano sonata (i.e., Mozart effect; see also Chabris et al., 1999). Likewise, in the study by Cockerton, Moore, and Norman (1997), background music facilitated cognitive test performance. In contrast, Ransdell and Gilroy (2001) reported that background music significantly interfered with word-processed writing; they suggested that unattended music might place heavy demands on working memory. It has also been shown that increasing complexity in background music is associated with an increase of extroverts', and a decrease of introverts', cognitive-task (e.g., memory test) performance (Furnham & Allass, 1999). However, most of the background music research has been focused on the effects of music on cognitive task performance, whereas the interactive effects of the two stimuli on emotional responses have been less investigated.

2 AIMS AND HYPOTHESES

As noted earlier, we argued for the multidimensional (and multidisciplinary) research procedure. Our theoretical approach is similar to Scherer and Zentner's model, which is among the first to try to systematize and define the multidimensionality of emotional reactions to music (see Scherer and Zentner, 2001; see also Scherer, Zentner, and Schaht, 2002). By multidimensional (and multidisciplinary) research approach we refer to an approach that consists of (a) measuring subjective responses (i.e., capturing the voluntary and conscious responses), psychophysiological responses (i.e., capturing also the involuntary and sometimes unconscious responses), and various traits (i.e., capturing personality, preferences, and other background factors), and (b) examining the relationships between the musical, individual, and contextual attributes that may influence emotions. This kind of research procedure may, on the one hand, produce more detailed information on the phenomenon that is studied. On the other hand, it enables more coherent analysis of the object, because the object of study can be examined from different points of view. However, this method produces huge amount of data, which usually cannot be dealt within a single article. Therefore, it might be beneficial that the articles that are methodologically or theoretically related to each others would also be examined from a wider theoretical perspective. In the seven articles we have used very similar methods, the focus has been in one way or another on the three attributes (musical, individual, or contextual) that influence emotional effects of music, and the results can be interpreted from a comprehensive theory of musical emotion.

We will first summarize the aims and hypotheses of each individual study. Then some "meta" questions are formulated, which could perhaps be answered on the basis of more than one of the papers. In general, in the studies I and II the focus of the research was on the emotional quality and effects of music per se. Studies III and IV focused more on the (multimodal) context of music in regard to listening to (study III) or reading (study IV) news, whereas in studies V, VI, and VII we focused especially on the individual differences in emotional responses to music.

2.1 Studies I and II

In the first paper we examined whether basic emotional music pieces could be identified in the art music repertoire and how the music pieces are organized in the Kohonen self-organizing map. Suggestions for basic emotional music excerpts were collected from music professionals by a survey. Participants with different level of musical expertise then listened to 78 pieces (in two different experiments) and rated the music in terms of basic emotions (i.e., joy, sadness, anger, fear surprise, and disgust), and intensity (low, medium, high, very high). The ratings were the input into Kohonen neural network, and the topological organizations of the pieces were examined using the output, i.e., the self-organizing map (SOM).

We expected that, basic emotional pieces of music with different intensity levels can be found, and on the basis of previous studies (e.g. Terwogt and Van Grinsven, 1991), that joy and sadness are more easily recognized in music than anger, fear, surprise or disgust. Since people are commonly more familiar with Baroque, Classical, and Romantic music than with Renaissance, 20th-century, and Modern music, we predicted that subjects would suggest more music based on the tonal system than music based on other systems. We also expected that subjects who listen to Classical music often and/or who possess a higher level of music education would evaluate the music pieces more competently (i.e., more in line with music professionals' suggestions) and coherently (i.e., higher agreement) than subjects with less musical training and knowledge of classical music. We also predicted that the basic emotions would be independent emotional categories that would organize themselves on different sides in the SOM.

The second paper aimed to examine the relationships and differences between the perceived quality of music (emotion perceived) and the individual's subjective responses to music (i.e., emotion felt). Subjects listened to music differing in terms of a priori basic emotional quality, and rated the music from the two perspective (i.e., emotion felt and emotion perceived) using adjectives derived from the circumplex model of emotion. That is, we focused on the valence and arousal, as well as positive and negative activity, dimensions of emotion. We also examined the moderating effects of personality (i.e., BIS, BAS, ImpSS, and N-Anx) on the emotional responses.

Given (a) that, in general, normatively negative and positive stimuli, such as pictures, elicit negative and positive emotional responses in viewers, respectively (e.g., Lang, 1995; Gable et al., 2000) and (b) the phenomenon of emotional contagion (i.e., when we perceive that someone else is sad, we also feel sad; see e.g., Hatfield et al., 1994), it was expected that, in general, music would evoke emotions similar to its perceived emotional quality (i.e., a positive relation between perceived and felt emotion; Hypothesis 1a). However, it is also possible that music would evoke emotions opposite to the perceived emotional quality (i.e., a negative relation between perceived and felt music; Hypothesis

1b). We also expected that high BIS scorers would exhibit higher felt negative emotion relative to perceived negative emotion, particularly when listening to negatively valenced music (Hypothesis 2a); high BAS scorers might, in turn, exhibit higher felt positive emotion relative to perceived positive emotion, particularly when listening to positively valenced music (Hypothesis 2b). Given that neuroticism is also related to a tendency to experience negative emotions (Canli et al., 2001), the pattern of responses exhibited by high N-Anx scorers would be expected to be similar to that exhibited by high BIS scorers (Hypothesis 3). Given that high sensation seekers prefer arousing music (they may seek stimulation in order to raise their arousal to the hedonic optimal; see Zuckerman, 1990), they would be expected to exhibit higher felt positive emotion relative to perceived positive emotion when listening to arousing music (Hypothesis 4). A hypothesis that is partly at variance with the previous ones would suggest that high BIS and N-Anx scorers would exhibit low felt arousal and positive affect relative to perceived arousal and positive affect (Hypothesis 5), given that they may not be easily emotionally engaged by music owing to their high inhibitory tendencies.

2.2 Studies III and IV

In study III, we examined the emotional effects of (a) a rising versus a falling chromatic tone sequence in the background of audio news and (b) foreground versus background diatonic and chromatic tone sequences. In experiment one, subjects rated audio news messages with rising and falling chromatic background tone sequences on the valence and arousal dimensions. Cardiac activity, electrodermal activity (EDA), and facial muscle activity were also recorded continuously. In experiment two, subjects rated six plain tone sequences (i.e., rising and falling chromatic, major, and minor) and six news messages with the aforementioned tone sequences mixed in the background on the valence and arousal dimensions.

In connection with experiment one, we hypothesized (hypothesis 1) that, in line with previous research, news with rising-tone sequences would elicit higher arousal than news with falling-tone sequences. We also hypothesized (hypothesis 2) that, in agreement with previous studies on diatonic melodies, chromatic rising-tone sequences would generate more pleasant responses than chromatic falling-tone sequences. An alternative hypothesis would be that, because a chromatic tone sequence lacks the connotations of diatonic melodies, there would be no difference in the emotional responses on the valence dimension elicited by news with rising and falling chromatic tone sequences.

In connection with experiment two, as in experiment 1, we expected that rising-tone sequences would prompt higher arousal and pleasantness ratings (hypothesis 1). We also expected (hypothesis 2) that foreground melodies would prompt responses related to the connotations of music as such (e.g., major is pleasant, minor is unpleasant), while background melodies would prompt responses influenced by the emotional tone of the news messages (e.g., minor tone sequences would be rated as most pleasant because of the congruency with the emotional tone [i.e., negative] of the news); this suggestion is based on the consistency-attraction principle (e.g., Nass and Lee, 2001). In line with Gerardi and Gerken (1995) and Collier and Hubbard (2001), it was also expected that the major mode tone sequences would be rated as most pleasant and the minor mode sequences as most unpleasant, while chromatic sequences would prompt pleasantness ratings falling between those of the two diatonic mode sequences (hypothesis 3).

As the third paper demonstrated it is important to study music as a background for other activities in addition to studying the effects of plain music. Evidently music has differential effects when listened in focus versus when listened incidentally. It is also of importance that music is most often used as a background accompaniment for everyday activities, such as driving a car or cleaning a house (see e.g., Sloboda et al., 2001). The fourth paper focused especially on the effects of background music on reading. The aim of the paper was to examine the effects of background music on reading business news in crowded cafeteria environment. Measures, which included reading time, - rate, and efficiency, as well as emotional judgements, were taken regarding three reading conditions: 1) no background music, 2) fast music and 3) slow music.

It was hypothesized that reading with background music with earphones enhances reading in distracting environments (hypothesis 1), because the background noise is attenuated. It was also predicted that subjects in the slow-music condition read slower than subjects in the fast-music condition (hypothesis 2). This hypothesis was based on previous studies, which suggest that fast music may accelerate performance (Roballey, 1985; McElrea & Standing, 1992; Nittono et al., 2000), whereas slow music may decrease it (Milliman, 1986).

2.3 Studies V, VI, and VII

As we have argued, there are many individual differences, such as personality, age, musical taste etc., which may moderate the emotional responses to music. In most of our studies we have also examined the effects of various background factors. For example, in paper II we examined the influences of BIS, BAS, ImpSS, and N-Anx on self-report emotions; In the papers V, VI, and VII we focused especially on personality related differences as indexed by psychometrical measures of BIS/BAS (Gray, 1982, 1991), and the Alternative Five (i.e., Zuckerman et al., 1993) on self-report (valence, arousal, PA, NA) and psychophysiological (i.e., EEG, EDA, EMG and cardiovascular) responses to music (study V), and reading (study VI) and listening to (study VII) news.

In paper V, we examined whether personality, defined in terms of behavioural inhibition system (BIS) and behavioural activation system (BAS) sensitivities and the Alternative Five personality dimensions, moderates the influence of a music listening session comprising 12 music pieces, on the emotional state of an individual as assessed by self-report and psychophysiological measures in 32 participants. Electroencephalographic (EEG) and cardiovascular (inter-beat intervals and pulse transit time) activity was recorded continuously during a 60-s eyes-open and a 60-s eyes-closed resting periods before and after the music listening session. Participants rated their mood instantly after the pre-music and post-music rest periods.

Given that music has been shown to increase positive feelings and reduce anxiety, stress, and negative feelings (e.g., Scheel and Westefield, 1999; Davis & Thaut, 1989), we expected that the affective state would change as more positive and aroused as from the pre- to post-music rest. We also expected that there would be more relative left and overall frontal activation during post-music compared to pre-music rest period (valence hypothesis; see e.g., Smith and Trainor, 2001). The hypothesized music-induced increase in arousal was also expected to be reflected by two cardiovascular parameters: (a) heart rate and (b) PTT mediated by the sympathetic nervous system (shorter PTT indicating higher arousal).

Given that music has been shown to increase positive feelings and reduce anxiety especially in anxious and depressed subjects (e.g., Hanser, 1990; Lai, 1999), we expected that the music listening session would have a positive effect especially among subjects scoring high on BIS sensitivity and N-Anx (i.e., neuroticism- and anxiety-related scales). However, an alternative hypothesis would be that the music listening session would have a positive influence among high BAS scorers, given that high BAS sensitivity results in strong responses to positive cues.

In paper VI, we examined the moderating influence of dispositional BIS and BAS sensitivities on the relationship of startling background music with emotion-related subjective and physiological responses elicited during reading news reports, and with memory performance among participants. Physiological parameters measured were respiratory sinus arrhythmia (RSA), electrodermal activity (EDA), and facial electromyography (EMG).

It would be expected, for example, that individuals scoring high on the BIS dimensions would react more strongly (e.g., greater negative arousal) to startling background music (i.e., a signal of punishment and novelty).

In paper VII, we examined the personality-related differences in people's emotional and other responses to news messages with a slow vs. a fast speech rate and a rising vs. a falling background music melody. We shall only report the hypothesis and results in regard to the musical stimuli (i.e., rising vs. a falling background music melody). Personality was measured with the BIS/BAS scales and the Zuckerman-Kuhlman Personality Questionnaire. Physiological parameters studied were electrodermal activity (EDA), pulse transit time, and interbeat intervals.

We hypothesized that subjects scoring high on sensation seeking, Sy, Act, and BAS sensitivity (i.e., extraversion-related personality dimensions) would prefer (as indexed by pleasantness ratings; hypothesis 1a) and be more (positively) aroused (as indexed by arousal ratings and EDA; hypothesis 1b) during the news with high-arousal stimuli (i.e., rising melody) compared to the news with low arousing stimuli (i.e., falling melody); in contrast, subjects scoring low on these dimensions or high on N-Anx and BIS sensitivity would be expected to prefer the news with a low-arousal stimuli. We also expected that subjects would evaluate also the other properties of the news (e.g., importance and understandability) more favourably (hypothesis 2) and pay more attention to the news (hypothesis 3) when the audio characteristics match their own personality; Recall that individuals preferentially process stimuli that are emotionally congruent with their stable personality traits (Rusting, 1998), and that similarity and liking may lead to more positive overall evaluations of the object (Bates, 2002).

2.4 Summary: List of the Hypotheses

Table 1 shows the summary of the hypotheses in studies I to VII.

TABLE 1 List of hypotheses in the original studies.

Study	H-no.	Prediction
I	1	Basic emotional pieces of music with different intensity levels can be found.
I	2	Joy and sadness are more easily recognized in music than anger, fear, surprise or disgust.
I	3	Subjects suggest more music based on the tonal system than music based on other systems.
I	4	Subjects who listen to Classical music often and/or who possess a higher level of music education evaluate the music pieces more competently and coherently than subjects with less musical training and knowledge of classical music.
I	5	Basic emotions are independent emotional categories that will organize themselves on different sides in the SOM.
II	1a	In general, music evokes emotions similar to its perceived emotional quality (there is a positive relation between perceived and felt emotion).
II	1b	It is also possible that music evoke emotions opposite to the perceived emotional quality (there is a negative relation between perceived and felt music)
II	2a	High BIS scorers exhibit higher felt negative emotion relative to perceived negative emotion, particularly when listening to negatively valenced music.
II	2b	High BAS scorers exhibit higher felt positive emotion relative to perceived positive emotion, particularly when listening to positively valenced music.
II	3	The pattern of responses exhibited by high N-Anx scorers is similar to that exhibited by high BIS scorers.
II	4	High sensation seekers exhibit higher felt positive emotion relative to

		perceived positive emotion when listening to arousing music.
II	5	High BIS and N-Anx scorers exhibit low felt arousal and positive affect relative to perceived arousal and positive affect.
III[1]	1	News with rising-tone sequences elicits higher arousal than news with falling-tone sequences.
III[1]	2	Chromatic rising-tone sequences generate more pleasant responses than chromatic falling-tone sequences.
III[2]	1	Rising-tone sequences prompt higher arousal and pleasantness ratings.
III[2]	2	Foreground melodies prompt responses related to the connotations of music as such, while background melodies prompt responses influenced by the emotional tone of the news messages.
III[2]	3	Major mode tone sequences would be rated as most pleasant and the minor mode sequences as most unpleasant, while chromatic sequences would prompt pleasantness ratings falling between those of the two diatonic mode sequences
IV	1	Reading against background music with earphones enhances reading in distracting environments.
IV	2	Subjects in the slow-music condition read slower than subjects in the fast-music condition.
V	1	Affective state changes as more positive and aroused from the pre- to post-music rest.
V	2	There will be more relative left and overall frontal activation during post-music compared to pre-music rest period.
V	3a	Music listening session have a positive effect especially among subjects scoring high on BIS sensitivity and N-Anx (i.e., neuroticism- and anxiety-related scales).
V	3b	Music listening session have a positive influence among high BAS scorers.
VI	1	Individuals scoring high on the BIS dimensions would react more strongly (e.g., greater negative arousal) to startling background music (i.e., a signal of punishment and novelty).
VII	1a	Subjects scoring high on sensation seeking, Sy, Act, and BAS sensitivity prefer (as indexed by pleasantness ratings) the news with a high-arousal stimuli compared to the news with a low arousal stimuli; in contrast, for subjects scoring low on these dimensions or high on N-Anx and BIS the opposite would be true.
VII	1b	Subjects scoring high on sensation seeking, Sy, Act, and BAS sensitivity will be more (positively) aroused (as indexed by arousal ratings and EDA) during the high-arousal stimuli compared to low arousal stimuli; in contrast, for subjects scoring low on these dimensions or high on N-Anx and BIS sensitivity the opposite would be true.
VII	2	Subjects evaluate also the other properties of the news (e.g., importance and understandability) more favourably when the audio characteristics match their own personality.
VII	3	Subjects would pay more attention to the news when the audio characteristics match their own personality.

2.5 General Questions

In addition to research problems and hypotheses stated in the individual papers, we wanted to examine whether more general conclusions on musical emotions can be made on the basis on all papers. The aim of the study series was to investigate the following general research questions, among other issues:

1) Does music differing in emotional tone (e.g., negative vs. positive, high-arousal vs. low-arousal) result in differential emotion- and attention-related psychophysiological and self-report response patterns.

2) What is the relationship between emotion perceived and emotion felt when listening to music?

3) Do temperament, personality, and music-related demographics moderate the cognitive-emotional responses to music?

4) What is the relationship between emotional quality of background music and a media message it is attached to?

5) What are the benefits of a "multidimensional research approach"?

3 SUBJECTS, MATERIALS, AND METHODS

The materials, subjects, and methods, which are briefly summarized below, are described in detail in the original publications I-VII.

3.1 Subjects and Materials

Participants were (mostly) non-musician Finnish women and men with different educational backgrounds. The number of participants ranged from 26 to 99. Materials consisted of previously rated emotional music and audio or written (business) news messages.

3.1.1 Study I

3.1.1.1 Subjects

In study I we had a survey and two music listening experiments. About 50 music professionals completed the survey. They were 20 music teachers and theorists, 5 composers, 15 instrumentalists, 3 singers and 7 professional music students.

There were 44 subjects in experiment 1 and 55 subjects in experiment 2. Of the total of 99 subjects, 74% were women, and 26% were men. The ages varied from 12 to 45 (M = 18.5). There were subjects with no musical training and with little experience in listening to classical music to professional music students with a lot of experience in listening to classical music. However, most of the subjects were music amateurs with several years of music training. They listened to western art music quite often, and evaluated themselves as quite competent in classical music repertoire.

3.1.1.2 Materials

Seventy-eight music pieces were selected from the total of 214 suggestions for music passages that typically express a particular (basic) emotion, and were used in the listening experiments. Music was randomly chosen from the pieces that were available as records and scores. Only instrumental music was considered to ensure that the listeners' responses would not be influenced by the lyrics. Twenty pieces expressing joy, 17 pieces expressing fear, 2 pieces expressing surprise, 18 pieces expressing anger, 19 pieces expressing sadness, and 3 pieces expressing disgust were chosen.

3.1.2 Studies II and V

These studies are based on the same experiment. Therefore the subjects, materials, and methods are the same.

3.1.2.1 Subjects

Subjects were 32 non-musician Finnish men (n = 11) and women with varying educational backgrounds, who ranged from 19 to 29 years of age (M = 23). In study V, all participants were included in the analyses of cardiovascular and self-report data, but because EEG data were unusable for some subjects (i.e., more than 60 % of the data contained eye-movement artefact in some of the four conditions) and seven subjects were left-handed, the number of participants included in the EEG analyses ranged from 18 to 25.

3.1.2.2 Music

We chose 12 pieces that differed in terms of their basic emotional quality as determined on the basis of ratings in the study I. We selected three pieces for each of the four a priori basic emotion categories – joy, sadness, anger, and fear. A one-minute excerpt from each of the 12 pieces was recorded on a computer. The 12 excerpts were presented in a random order during the music listening session.

3.1.3 Studies III, VI, and VII

These studies were carried out as a small series of experiments that the subjects participated during a one longer experimental session. Therefore, the subjects were the same in all of these studies (except in the second experiment in the paper III, which was run separately).

3.1.3.1 Subjects

Subjects were 26 (24 in the experiment 2 of the study III) Finnish non-musician men (n = 10) and women with varying educational backgrounds, who ranged from 20 to 62 years of age (*M* = 32). Given that physiological data were unusable for some subjects for varying reasons, the number of subjects ranged from 21 to 26 in the statistical analyses.

3.1.3.2 Materials

In the study III, we used (a) rising and falling chromatic tone sequences in the background of business news stories that, on the basis of a pre-test procedure (Ravaja, 2004), were judged to be negative on the valence dimension and low on the arousal dimension (experiment 1) and (b) foreground versus background diatonic and chromatic tone sequences (experiment 2). In experiment 1, we used chromatic piano sequences in the background of recordings of about 50-second business news stories that were read by a professional newscaster. In experiment 2 we had rising and falling chromatic and diatonic (minor and major mode) piano sequences both with and without the news stories used in experiment 1. The rising-tone sequences consisted of pairs of quarter notes from E1 to sharp G5, and the falling-tone sequences of pairs of quarter notes from sharp G5 to E1, in the tempo of 66 beats per minute. The tone sequences were composed with a midi program so that the dynamics were "monotonically" the same for every individual note. The piano parts were mixed in the background of the audio news using a -16db volume level. The volume levels of all audio files were standardized and balanced approximately to 72 dB (fast SPL) by the Sound Forge audio processing program's normalizing function.

In the study VII, we had (a) the same stimuli as in the experiment 1 in the study III and (b) fast and slow speech rate audio news (see Kallinen and Ravaja, 2005). In the study VI we compared the effects of a modified and a nonmodified version of the second movement of the Haydn's "Surprise" symphony (No. 94) on emotional responses and knowledge acquisition from news messages. In the modified version we intensified the kettledrum fortissimos by adjusting the loudness and rise time to ensure that the kettledrum fortissimos would elicit a startle response. The news messages were six stories representing the same valence-arousal combination (i.e., negative-high arousal). Each of the six news stories had two versions, one accompanied by background music with kettledrum fortissimos (i.e., startling music) and one by background music without kettledrum fortissimos (i.e., non-startling music). The news stories were of approximately equal length (81 to 87 words).

3.2 Methods

We used most often within subjects designs and analysed the data with the GLM repeated measures procedure. As discussed previously in the paper, we have applied a multidimensional research approach in which we have tried to examine a wide range of listeners' responses to music (and media stimuli) including subjective and conscious, as well as objective and (sometimes) unconscious and contextual factors. Measurements have consisted of (a) self-reports that have been used to capture the subjective experiences (such as emotions), personality and other background factors as well as task performance (e.g., memory performance), and (b) psyhophysiological measurements that have been used to capture the responses related to emotions and attention.

3.2.1 Measures

3.2.1.1 Demographics

Background factors such as age, gender, level of education, level of musical education, music listening preferences and habits were assessed with a questionnaire.

3.2.1.2 Personality and Temperament (Studies II, V, VI, and VII)

The Zuckerman-Kuhlman Personality Questionnaire (ZKPQ) is a 99-item self-report measure that was used to assess the participants' basic dimensions of personality (Zuckerman et al., 1993). The ZKPQ comprises five scales. The ImpSS scale consists of 19 items (e.g., "I tend to begin a new job without much advance planning on how I will do it"), and can be divided into two subscales: (a) the impulsivity (Imp) dimension describes a lack of planning and a tendency to act impulsively and (b) the sensation seeking (SS) dimension describes a general need for thrills and excitement. The N-Anx scale consists of 19 items (e.g., "I am not very confident about myself or my abilities") that describe emotional upset, tension, worry, fearfulness, obsessive indecision, lack of self-confidence, and sensitivity to criticism. The Agg-Host scale consists of 17 items (e.g., " I enjoy seeing someone I don't care for humiliated before other people") that describe a readiness to express verbal aggression; a tendency to rude, thoughtless, or antisocial behaviour; vengefulness and spitefulness; a quick temper; and impatience with others. The Act scale consists of 17 items (e.g., " I do not like to waste time just sitting around and relaxing") that describe a need for general activity, impatience and restlessness when there is nothing to do, preference for challenging and hard work, and a lot of energy for work and other tasks. The Sy scale consists of 17 items (e.g., "I tend to start conversations at parties") that describe liking of big parties, having many friends, intolerance for social isolation, and disliking solitary activities.

Dispositional BIS and BAS sensitivities of the participants were measured with the BIS/BAS scales (Carver & White, 1994), a 20-item self-administered questionnaire. The BIS scale is comprised of 7 items (e.g., "I feel pretty worried or upset when I think or know somebody is angry at me"). The BAS scale is comprised of three subscales: BAS Drive (DR) reflects the persistent pursuit of desired goals (4 items; e.g., "I go out of my way to get things I want"); BAS Fun Seeking (FS) reflects both a desire for new rewards and willingness to approach a potentially rewarding event (5 items; e.g., "I crave excitement and new sensations"); and BAS Reward Responsiveness (RR) reflects the orientation to respond positively to the occurrence or anticipation of reward (4 items; e.g., "When I get something I want, I feel excited and energized"). Each of the items was rated on a 4-point scale, ranging from 1 (very false for me) to 4 (very true for me). The psychometric properties of the instrument have been shown to be acceptable (Carver & White, 1994).

3.2.1.3 Self-Report Emotions

Subjects rated their emotional reactions in terms of (a) basic emotions using pictures of facial affect (study I; see figure 2), (b) valence and arousal using 9-point pictorial scales presented on a computer screen (studies III, VI, and VII; see figure 3), (c) valence, arousal, positive activation, and negative activation using 5-point scales that consisted of 16 adjectives chosen from the emotion-circumplex (studies II, and V; see figure 4), or (d) a bi-polar scale (negative vs. positive; study IV; see figure 5).

In study I, we used pictures for facial affect that consisted of eight photographs, which were chosen from the book by Paul Ekman and Wallece V. Friesen (1975) and coded with capital letters A, B, C, D, E and F and given on an A4-sized sheet (see figure 1). Subjects rated the music excerpts using the pictures and intensity scale consisting of four statements (i.e. low intensive, moderate intensive, high intensive, and very high intensive).

FIGURE 2 Basic emotional facial expressions.

As illustrated in figure 3, the valence scale used in studies III, VI, and VII consists of 9 graphic depictions of human faces in expressions ranging from a severe frown (most negative) to a broad smile (most positive). Similarly, for arousal ratings, there were 9 graphical characters varying from a state of low visceral agitation to that of high visceral agitation. The ratings were made by selecting a radio button below an appropriate picture. These scales resemble P. J. Lang's Self-Assessment Manikin (Lang et al., 1993).

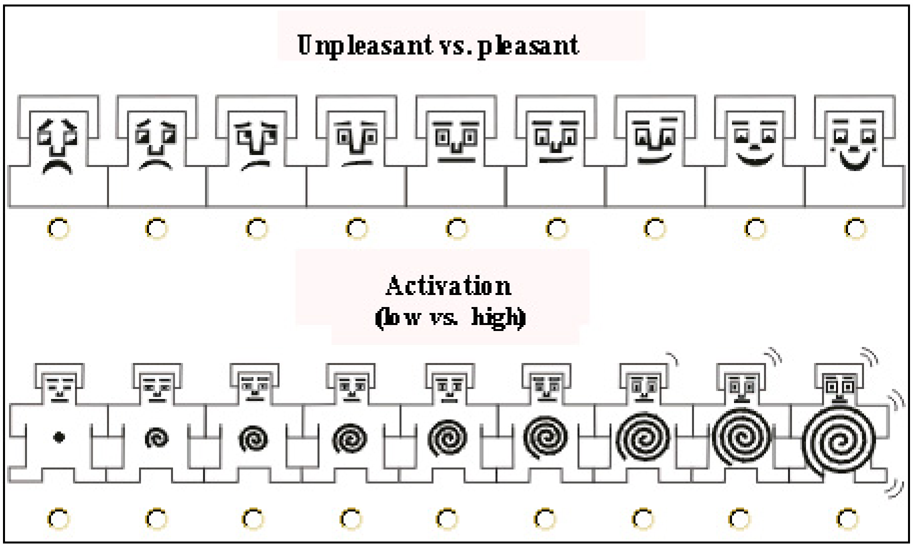

FIGURE 3 The pictorial scales for valence and arousal.

Valence (ranging from positive to negative), arousal (ranging from high to low), PA (ranging from high PA to low PA) and NA (ranging from high NA to low NA) was assessed in studies II and V using affect terms presented in Figure 4 (there were two affect terms for each end of each dimension). Each of the items was rated on a 5-point scale, ranging from 1 (not at all) to 5 (very much). Scores for the four affective dimensions were calculated as follows: (a) valence: the sum of Positive items minus the sum of Negative items and (b) arousal: the sum of High Activation items minus the sum of Low Activation items, (c) PA: the sum of High PA items minus the sum of Low PA items and (d) NA: the sum of High NA items minus the sum of Low NA items. Thus, the maximum and minimum values on these dimensions ranged from 8 to –8.

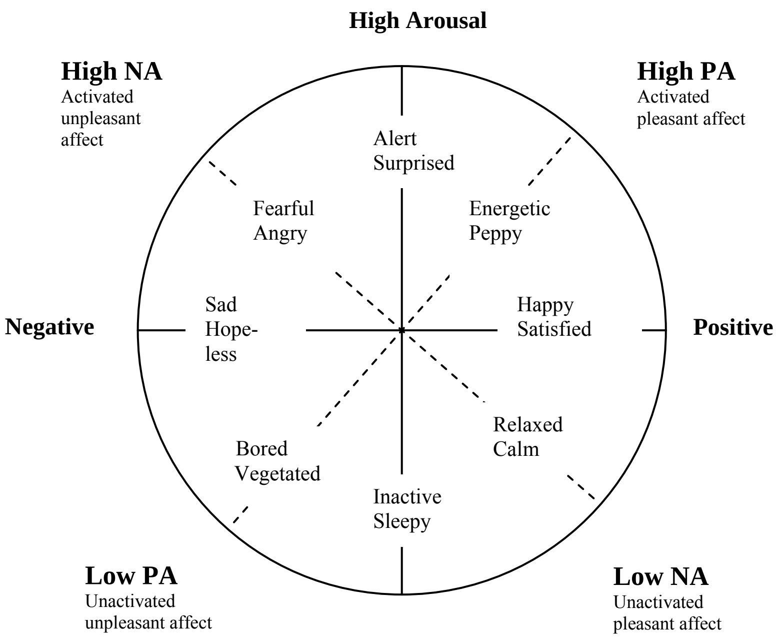

FIGURE 4 The two-dimensional structure of affect, showing the dimensions of Positive Activation (PA) and Negative Activation (NA) on the diagonals and their relationship to the alternative dimensions of Valence (horizontal) and Arousal (vertical), as well as the 16 affect terms used to measure current mood. Adapted from Larsen and Diener (1992) and Watson et al. (1999).

In study IV, the valence of the a priori neutral news messages that subjects read in the fast-music -, slow-music -, or no music conditions was assessed with a five point continuous scale (-2, -1, 0, +1, +2; see figure 5). The subject was told that she or he could evaluate the valence of the news messages by marking a cross in anywhere between the poles.

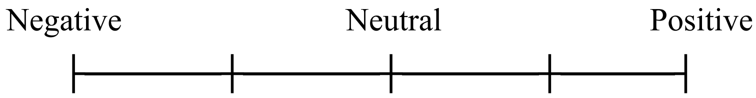

FIGURE 5 A bipolar scale for a valence dimension of emotion.

3.2.1.4 Other Ratings (Studies VI and VII)

The subject rated the news on the following dimensions: interest (study VI), understandability, importance for society/economy, and importance for the self (study VII). The ratings were made using a 5-point scale, ranging from 1 (e.g., not interesting at all) to 5 (e.g., very interesting). The scale was presented on a computer screen.

3.2.1.5 Behavioural Measures (Studies II, IV, VI)

The reading time was measured in seconds (study IV and VI). The reading comprehension was calculated with the formula: number of right answers/total number of questions and the reading efficiency was calculated with the formula: reading rate (words per minute) * reading comprehension (study IV; see Carver, 1990). Seven true-false statements were used to assess the knowledge acquisition in the study IV. In study III a set of 12, in study VI a set of 18, and in study VII a set of 18 (experiment 1) and 12 (experiment 2) multiple-choice questions (three questions per news story) was used to assess the amount of knowledge acquired from the stories. There was one correct answer to each question, and three plausible alternatives were constructed for each question. The questions were rearranged for each reading order so that items about each story were presented in the order that the stories were read.

3.2.1.6 Psychophysiological Measurements (Studies III, V, VI, and VII)

3.2.1.6.1 Electrodermal Activity (EDA)

Skin conductance was recorded with the Psylab Model SC5 24 bit digital skin conductance amplifier that applied a constant 0.5 V across Ag/AgCl electrodes with a contact area of 8 mm diameter (Med Assoc. Inc., St. Albans, VT). Electrodes were filled with TD-246 skin conductance electrode paste (Med Assoc. Inc.) and attached to the middle phalanges of the first and second fingers of the subject's nondominant hand after hands were washed with soap and water. EDA was indexed as the frequency of non-specific skin conductance responses (NS-SCR freq.).

3.2.1.6.2 Cardiac Activity

Electrocardiogram (ECG) was recorded using the Psylab Model BIO2 isolated AC amplifier (Contact Precision Instruments). Three Red Dot Ag/AgCl electrodes (3M Health Care, Borken, Germany) were placed in a modified Lead II position.

Peripheral pulse signals were recorded using the Psylab Model PPA2 peripheral pulse amplifier, together with a Psylab (Model PT1) photo-plethysmograph transducer placed on the ring finger of subjects' nondominant hand. PTT (ms), the interval between the ECG R-wave and the onset of the finger pulse wave, was registered using two Psylab Interval Timers that were linked together. One interval timer registered R-waves and measured the intervals between the successive R-waves, i.e., interbeat intervals (IBIs). The other interval timer, with its analog waveform input linked to the PPA2 amplifier, measured PTT.

3.2.1.6.3 Respiratory Sinus Arrhythmia (RSA; Study VI Only)

To quantify RSA, the ECG data were analyzed off line by using WinCPRS software (Absolute Aliens Ay, Turku, Finland). The R-peaks were detected using a digital filter and fitted with a polynomial of a second order. After deriving an R-R interval series, the R-peak detection results on the ECG signal were edited manually and the R-R interval series was automatically updated. The interbeat interval (IBI) data were then resampled into equal time intervals every 200 ms. The nonstationary component was removed from the IBI time series by using a cubic order moving polynomial filter with a duration of 10.5 s, and a residual series was generated (Porges and Bohrer, 1991). All later operations and computations were performed separately for the first 30-s residual data segment of each news story. The data segments were windowed (Hanning window) and subjected to spectral analysis using the fast Fourier transform (FFT) technique. The computed spectrum was smoothed using a triangular averaging function. RSA was indexed by the spectral power for the 0.15-0.40 Hz frequency band. The RSA data were transformed with a natural logarithm and reported in units of $\ln(\mathrm{ms})^2$.

3.2.1.6.4 Electromyographic Activity (EMG; Studies III, VI, and VII)

Facial EMG activity was recorded from the left corrugator supercilii (CS), zygomatic major (ZM), and orbicularis oculi (OO) muscle regions as recommended by Fridlund and Cacioppo (1986), using surface Ag/AgCl electrodes with a contact area of 4 mm diameter (Med Assoc. Inc.). Electrodes were filled with TD-240 electrode gel (Med Assoc. Inc). The raw EMG signal was amplified, and frequencies below 30 Hz and above 10 kHz were filtered out, using the Psylab Model EEG8 amplifier. The raw signal was rectified and integrated using the Psylab INT8 contour following integrator (time constant = 50 ms). The digital data collection was controlled by Psylab7 software, and all physiological signals were sampled at a rate of 500 Hz.

3.2.1.6.5 Electroencephalography (EEG) Recording and Data Reduction (Study V Only)

EEG was recorded using the ECI-Electrocap system (Electro-Cap International, Eaton, OH). The cap electrodes were positioned according to the International 10/20-system. The EEG was recorded at eight scalp locations: left and right frontal (F3, F4), central (C3, C4), temporal (T7, T8), and parietal (P3, P4) regions. The electrodes were referred to vertex (Cz), and the ground electrode was located at the midforehead (AFz). Impedance at each electrode site was maintained below 5 KΩ. Eye movements (EOG) were also recorded to facilitate artefact scoring of the EEG. All data were acquired at a sampling rate of 500 Hz. The data were partitioned into 2-s epochs and inspected for the presence of artifacts. All artifact-free EEG data were then analysed using the fast Fourier transform (FFT) technique, with a Hanning window of 2-s width and no overlap. Power estimates (mV^2) were derived from the fast Fourier transform FFT in the theta (3.5–7 Hz), alpha (8-13 Hz), and beta (13–30 Hz) EEG bands. The power spectral estimates for successive 2-s epochs were averaged across each condition. Mean spectral estimates for each condition were then natural log-transformed.

3.3 Data analysis

3.3.1 Study I

Descriptive statistical methods, cross-tabulation, Chi-square tests, and SPSS's General Linear Model (GLM) Univariate Procedure were used to analyze the survey data and data from the listening experiments. The organization of the pieces of music in the basic emotion space was visually examined using the self-organizing map (SOM) that was produced by Kohonen's neural network.

3.3.2 Studies II, III, V, VI, and VII

Data were analyzed by General Linear Model (GLM) Repeated Measures procedure in SPSS. In Study I we had two within-subjects factors, i.e., type of rating (felt, perceived) and a priori basic emotion (joyful, fearful, and sad). In study III, we had two or three within-subjects factors, i.e., type of tone sequence (falling, rising), story position (1^{st}, 2^{nd}), and time (for physiological measures, three 16-s epochs) in experiment 1, and three within-subject factors, i.e., type of listening task (2 levels: foreground, background), contour direction (2 levels: falling, rising), and tone sequence type (3 levels: major, minor, and chromatic) in experiment 2. In study V, we used condition (pre-music rest, post-music rest) and mode (eyes open, eyes closed) as within-subjects factors in connection with affective ratings, and 2 (condition: pre-music, post-music) x 2 (mode: eyes-open, eyes-closed) x 4 (site: frontal, central, parietal, temporal) x 2 (hemisphere: left, right) within-subjects factors in connection with EEG. Condition, mode, and time (for cardiovascular measures, three 20-s epochs) were used as within-subjects factors in connection with ECG data. In study VI, we used type of background music (2 levels: startling, non-startling), story position (3 levels: 1^{st}, 2^{nd}, 3^{rd}), and time (for EDA and EMG, 6 levels: the first six 5-s epochs during news reading) as the within-subjects factors. In study VII, we had two or three within-subjects factors i.e., speech rate (fast, slow), story position (1^{st}, 2^{nd}, 3^{rd}), and time (three 10-s epochs from the beginning of the news for physiological measures) in experiment 1; and melody type (ascending, descending), story position (1^{st}, 2^{nd}), and time (three 16-s epochs for the physiological measures) in experiment 2. In above-mentioned analyses, continuous independent variables (e.g., age, Imp, BAS sensitivity) were used, each in turn, as a covariate, while gender was used as a between-subjects factor. The baseline physiological value was also used as a covariate (see e.g., Weidner, Friend, Ficarrotto, and Mendell, 1989). Significant interactions were graphed for participants receiving low (1 SD below the mean) and high (1 SD above the mean) scores on the moderator variable (e.g., age, BIS score; see Aiken and West, 1992).

In studies II and IV we also used contrasts to compare the different categories of the within-subject factor. The contrasts were orthogonal within the analyses of each dependent variable.

Because of the number of analyses, a potential margin of error exists in obtaining statistically significant results by chance. To minimize this potential error in results, in study II only the main effects and interactions at level $p \leq .01$ or higher were presented and discussed.

3.3.3 Study IV

The data were analyzed by the General Linear Model (GLM) Univariate procedure in SPSS, with reading time, reading comprehension, reading efficiency, and emotional character judgment, each in turn, as the dependent variable and with the reading condition, gender, field of education, disturbance judgment of the background music and previous palm-held PC experience, each in turn, as fixed factors. The effect of music volume was analyzed by treating it as the covariate.

4 RESULTS AND DISCUSSION

4.1 Studies I and II

4.1.1 Results

In connection with the survey for basic emotional music extracts, we found that the most frequently suggested emotions were sadness (24.8%), and joy (23.4%). The next most frequently suggested emotions were anger (11.7%) and fear (11.2%). Surprise and disgust got only a few mentions. There were also many words other than those expressing basic emotions that were suggested in the survey, such as pain, monotony, hope, bitterness, beauty, and energy. We also found that, romantic era pieces were most frequently suggested (36.0%). There were also many suggestions from the Baroque era (25.7%), Classicism (19.6%) and the 20th-century (tonal) music repertoire (11,2 %). However, pieces from the non-tonal music periods (i.e. Renaissance and Modern) were suggested less frequently.

With regard to emotion categories and music eras, joyful and sad pieces were most suggested in the Baroque era repertoire, whereas the relative frequency of pieces expressing anger and fear increase from Baroque to Romanticism, and the relative frequency of pieces expressing other than basic emotions increase from Classicism (16.7%, i.e. 7 out of a total of 42) to Romanticism (26.0%, i.e. 20 out of 77) to 20th-century tonal music (29.2%, i.e. 7 out of 24) to Modern music (66.7%, i.e. 8 out of 12).

The listening experiments showed that the listeners' evaluations of the pieces of music corresponded highly to the music professionals' evaluations. The degree of the listener agreement (mode frequency) on the emotional quality of the pieces of music ranged from 31 percent to 98.2 percent. The number of 'typical' basic emotional pieces of music, as well as the mode frequency, was higher in regard to the pieces of music expressing sadness (i.e. 17 out of 19 pieces with a mean mode frequency of 78%) and joy (i.e. 13/20; 76%) than those pieces of music expressing anger (i.e. 9/18; 58%), and fear (i.e. 4/17; 56%). None of the two pieces that were expected to express surprise or the three pieces that were expected to express disgust were evaluated as expected. We found that the background factors (e.g. level of music education, age and gender) had no effect on how well the subjects' evaluations matched (1) with the suggested emotion in the survey or (2) the mode of the evaluations.

The SOM indicated that the different emotions organize themselves into different corners in the map. We found that the joy, sadness, anger and fear emotions were quite far from each other. However, the distance between fear and anger was a little shorter than the distances between the other basic emotions. Neither of the two pieces that were expected to be perceived as surprising were evaluated as expected. However, the surprise evaluations were strongly associated with two other pieces of music, and weaker with many other pieces.

In the study II, we found that perceived and felt emotions were very similar (a) for joyful music on the valence (positive, *M*s = 5.06 and 4.76), arousal (relatively high, *M*s = 3.60 and 2.04), PA (relatively high, *M*s = 5.60 and 4.13), and NA (relatively low, *M*s = -0.88 and -2.30) dimensions; (b) for fearful music on the arousal (relatively high, *M*s = 3.43 and 2.20) and PA (relatively high, *M*s = 2.63 and 1.65) dimensions; and (c) for sad music on the valence (negative, *M*s = -4.64 and -2.40), arousal (low, *M*s = -0.28 and -0.65), PA (relatively low, *M*s = -0.15 and -0.44), and NA (relatively low, *M*s = -1.81 and -2.48) dimensions.

We also found that perceived and felt emotions were different for (a) negative (fearful and sad) vs. positive (joyful) music on the valence ($p < .001$), and (b) fearful vs. joyful and sad music on the NA ($p < .001$) dimensions. We found that felt emotion was more positive than perceived emotion in connection with negative music, whereas, in connection with positive music the opposite was true. We also found that although all music elicited lower felt than perceived NA, this was especially true for fearful music.

We also found several main effects when comparing emotion perceived versus emotion felt per se. Level of felt emotions was higher than the level of perceived emotions in connection with positive valence ($p < .001$), but lower in connection with arousal, PA, and NA (*p*s < .001).

The analysis also revealed significant Type of Rating × BIS ($p <.001$), and Type of Rating × N-ANX ($p < .01$), interactions in predicting arousal ratings, and Type of Rating × BIS, interaction in predicting PA ratings ($p < .01$). We found that the difference between perceived and felt arousal was higher among high BIS and high N-ANX scorers than among low BIS and low N-ANX scorers. Similarly, the difference between perceived and felt PA was higher among high BIS than among low BIS scorers.

4.1.2 Discussion

As we expected, in study I, we identified basic emotional music excerpts with different emotional intensity levels and generally the listeners were able to identify the emotional quality of the excerpts. The music listeners' agreement on the emotional quality of the music was in many pieces as high as 70 to 90 percent. The results support previous research that suggests that basic emotional qualities in music can be identified and to some extent predicted (e.g. Hevner, 1936; Terwogt and Van Grinsven, 1991; Juslin, 2001). Results also suggest that pieces are easiest to suggest from the tonal music repertoire and that the sad and happy pieces are more frequently suggested and recognized than fear and anger pieces (see Terwogt and Van Grinsven, 1991; Robazza et al., 1994). The music professionals suggested more frequently music pieces based on the diatonic major/minor system (i.e. Baroque, Classicism, and Romanticism) than music based on other systems' (i.e. Renaissance, 20th-century and Modern). In connection with emotion categories we found that the number of joyful and sad pieces was higher than other emotions in the survey and the consensus in evaluations in the listening experiments, as well as the number of 'typical' pieces, was higher in regard to sadness and joy than in regard to anger or fear, and especially in regard to surprise or disgust. We argued that the reason for a high number of pieces related to tonal system might be that the emotional connotations of other systems (especially modern music) are not so well established as in music related to the tonal system. Similarly, the high number of joyful and sad pieces may be due to the fact that they are more easily expressed and recognized in music. Other reasons for high amount of tonal pieces and pieces expressing joy and sadness could be because of the amount of exposure they get, given that the majority of the classical music one hears in radio and concerts is more or less from the "tonal" eras as contrast to modern music, and given that music has traditionally been composed for enjoyment, aesthetic pleasure, and practical purposes, such as masses, funerals and festivals, in which the expression of negative emotions (except sorrow) may have been attenuated.

Contradictory to our expectations, there was no difference in the "competence" in making affective judgments in regard to background factors (such as gender or musical education). Thus the results were consistent with some previous studies, which suggest the identification of emotions in music seems to be little influenced by background factors such as the level of music education, age or gender (see, e.g., Kratus, 1993; Kreutz et al., 2002). However, it should be acknowledged that in the present experiment subjects judged pieces only with six basic emotion categories and the pieces were chosen to represent the best and "purest" exemplars of each emotion. Future research should examine whether the finer-level cognitive and emotional judgments on music are enhanced by exposure and education on a given type of music (see e.g., Kallinen, in Revision; Kallinen, 2003; Kallinen, 2004).

In connection with the Kohonen neural network, the evaluations of music excerpts were organized into different corners on the SOM, suggesting that the basic emotions are distinct emotional categories in music. However, there were also many pieces that were located between the basic emotions. Accordingly, there were many other than basic emotion terms in the survey. According to the basic emotion theory, these pieces of music or affective terms might express some secondary emotion. Another explanation would be that in addition to very basic dimensions of emotions, the musical emotions are many and heterogeneous. Nevertheless, in sum, the Kohonen SOM seems to be an illustrative way to examine the organization of emotional music excerpts.

The data of study II confirmed our Hypothesis 1a, which stated that in general, music would evoke emotions similar to its perceived emotional quality. We found that perceived and felt emotions were very similar (a) for joyful music on the valence (positive), arousal (relatively high), PA (relatively high), and NA (relatively low) dimensions; (b) for fearful music on the arousal (relatively high) and PA (relatively high) dimensions; and (c) for sad music on the valence (negative), arousal (low), PA (relatively low), and NA (relatively low) dimensions. Thus, the results give support for the positive relation between perceived and felt emotion. Music may inherently possess such qualities that are both recognizable and elicit emotions. For example, fast-tempo music that is in a major mode with a consonant and easy listening harmony, may not only be an icon for positively valenced and arousing music (see e.g., Juslin, 2001), but may also elicit pleasure and high arousal (see e.g., Witvliet and Vrana, 1995 and 1996).

We also got partial support for the Hypothesis 1b, which stated that music may also evoke emotions different or opposite to the perceived emotional quality. The most notable difference between the perceived and felt emotion was that the fearful music was perceived as negative and as being relatively high on the NA dimension, but felt as relatively positive and as eliciting no NA. We argue that the reason for a positively valenced feeling when listening to fearful music (negative perceived emotion) may be that it generates excitement in listeners in a safe and controllable way, as in thriller movies. Music as an emotional object is different from real life emotional situations, because music does not pose a real threat to people. With music people are able to confront and deal with negative emotions in a safe and positive way. Another reason for positive reactions to fearful music may be its arousing properties. In an experiment where subjects have to stay still for a long time, any high-arousal stimulus might generate positive reactions because it decreases boredom and tiredness. However, more research is needed to validate these ideas.

Our Hypothesis 2a, which stated that high BIS scorers would exhibit higher felt negative emotion relative to perceived negative emotion, particularly when listening to negatively valenced music; Hypothesis 2b, which stated that high BAS scorers might exhibit higher felt positive emotion relative to perceived positive emotion, particularly when listening to positively valenced music; and Hypothesis 3, which stated that the pattern of responses exhibited by high N-Anx scorers would be expected to be similar to that exhibited by high BIS scorers, were not supported. Contradictory to Hypothesis 2a and 3, we found that the difference between perceived and felt arousal was higher among high BIS and high N-ANX scorers than among low BIS and low N-ANX scorers, and that the difference between perceived and felt PA was higher among high BIS than among low BIS scorers. Given that sensation seeking is negatively correlated to BIS (i.e., high sensation seekers score low on BIS; see study I), the results can be interpreted to give partial support for the Hypothesis 4, which predicted that high sensation seekers would be expected to exhibit higher felt positive emotion relative to perceived positive emotion when listening to arousing music (see Zuckerman, 1990), and Hypothesis 5, which stated that high BIS and N-Anx scorers would exhibit low felt arousal and positive affect relative to perceived arousal and positive affect. The results may suggest that individuals characterized by neurotic behaviour and anxiety tend to evaluate stimuli as more emotional, but may nevertheless be unable to engage emotionally with them owing to their high inhibitory tendencies.

In sum, the results suggest that, in general, music seems to arouse emotions similar to the emotional quality perceived in music. The study was among the first to examine the relationships between emotion perceived and emotion felt in a systematic and coherent way (see e.g., Swanwick, 1973, 1975; Gembris, 1982). However, some caution over the results may be warranted because of a relatively small number of subjects, a limited sample of music in the classical music genre, and the possible interference of reporting both perception and induction at the end of the same listening segment.

The focus of the research in study I and II was on the emotional qualities of music per se. We examined the perceived basic emotional categories (study I), as well as the differences in emotion perceived and emotion felt (study II) in responses. Taken together, studies I and II suggest that even though a wide range of emotional responses are attached to listening to music, in a very rough scale people may agree highly on the emotional quality of music and respond to it in a manner that is sometimes predictable. Music seems to often arouse emotions similar it is expressive for, even though negative emotions may be difficult to elicit.

However, recently a kind of research that takes no interest on the context of music listening, or the individual differences (e.g., musical preferences) in listeners has been criticized. The same music may have very differential effects on different people owing to their personality, musical preferences and age, for example. The emotional effects of music may also be very different in different contexts, such as when listening to music in a concert versus when listening to music while reading a newspaper. It has also been criticized that usually music has been used as uniform entity in experiments. That is, the different structural characteristics of music have not been controlled. And yet, music may have unambiguous emotional effects due to its rich structure. Therefore, in studies III and IV we especially examined the effects of structural features such as rising and falling contour and tempo and the multimedia context (i.e., listening to music while listening or reading to news) on emotional and other responses to the stimuli. In studies V, VI, and VII, in turn, the focus of the research was more on the individual differences (especially personality generated differences) in responses.

4.2 Studies III and IV

4.2.1 Results

In the experiment 1 in the study III, we found that the news was rated as more arousing and elicited a higher NS-SCR freq. in the rising-tone sequence condition than in the falling-tone sequence condition ($p < .05$ and $p < .01$). We also found a significant Condition × Age interaction in predicting NS-SCR freq ($p < .01$), and a Type of Background Tone Sequence × Computer User Experience interaction in predicting orbicularis oculi EMG activity ($p < .01$). The rising-tone sequence elicited a higher NS-SCR freq. compared to the falling-tone sequence, especially in the younger subjects, whereas among the older subjects the opposite was true. It was also observed that the subjects with less experience in using computers showed more orbicularis oculi activity during the news with a falling-tone sequence than during the news with a rising-tone sequence, whereas, among people with more computer user experience, the opposite tended to be true.

In the second experiment in the study III we found that rising-tone sequences prompted higher pleasantness and arousal ratings than falling-tone sequences ($p < .05$ and $p < .001$). We also found a significant Type of Listening Task × Tone Sequence Type interaction in predicting pleasantness ratings ($p < .05$). For foreground tone sequences, major mode versions prompted higher pleasantness ratings compared to chromatic and minor mode versions, whereas, when presented in the background of the news messages, minor mode versions prompted highest, chromatic versions next highest, and major mode versions the lowest pleasantness ratings.

The data of the study IV, showed that the reading was fastest and most efficient with fast tempo background music, slowest and least efficient with slow tempo background music, and between the two, with no background music ($p = .011$, for reading time and $p = .032$ for reading efficiency). Contrasts revealed that the differences between the no-music and music condition, and fast and no-music condition, were not significant. However, a significant difference between the no-music group and the Bach-slow group in reading efficiency was revealed ($p = .042$). Contrasts revealed also a significant difference in reading time ($p = .003$) and reading efficiency ($p = .014$) between the two music groups. The reading time was higher and the reading efficiency poorer in the slow-music group than in the fast-music group.

Significant gender differences between the three conditions were also found. The Condition x Gender interaction was significant for reading time ($p = .024$). Reading was slowest among women in the no-music group, whereas among men it was slowest in the Bach-Slow group. However, both men and women read the news most efficiently in the Bach-fast group. A significant Condition x Gender interaction was also revealed in predicting pleasantness ratings ($p = .021$). Women judged the news most positively in the no-music, and most negatively in the slow-music condition, whereas men evaluated the news most positively in the slow-music condition.

4.2.2 Discussion

As expected in study III, the rising-tone sequence condition elicited more arousal as measured by self-report and NS-SCR freq (Hypothesis 1 in experiment 1 and 2), and higher pleasantness ratings (Hypothesis 1 in experiment 2) than a falling-tone sequence. The results suggest that rising contours are generally related to higher arousal and pleasantness, even though the pleasantness difference was not observed in the first experiment. We argue that the rising and falling-tone sequences might be inherently arousing and sedating, respectively. This suggestion is supported by the way children and adults use prosody in infant-directed speech and singing (e.g., Ferhald et al., 1989). That is, rising contours are usually associated with high-arousal (e.g., attention-getting) purposes and falling contours with low-arousal (e.g., soothing) purposes (Fernald, 1992; Papoušek, Papoušek, and Symmes, 1991).

As also expected (Hypothesis 2 in experiment 2), the response patterns were different for foreground (focused-listening) and background (non-focused-listening) tone sequences. Foreground tone sequences prompted responses presumably associated with musical connotations, while the responses to news messages with background tone sequences appeared to be influenced by both the tone sequences and the emotional tone of the news. In the foreground tone sequence condition, the major mode versions prompted highest and the minor mode versions lowest pleasantness ratings, whereas, in the background tone sequence condition, the minor mode versions that were congruent with the emotional tone of the news (i.e., negative) were evaluated as most pleasant. This result is consistent with the findings showing that congruencies between the different characteristics of stimuli result in more positive responses (e.g., Nass and Lee, 2001).

We found only partial support for the third hypothesis in experiment 2, which, in line with the previous studies, stated that the major mode versions would be evaluated as most pleasant and the minor mode versions as most unpleasant. As noted above, the hypothesis was partially supported in the case of foreground tone sequence listening, thus implying that, in music, the major mode is usually related to more positive emotions and the minor mode to more negative emotions, whereas the chromatic sequences fall between the two. The result supports previous findings on the major/minor-related differences in emotional responses (e.g., Hevner, 1936; Gerardi and Gerken, 1995; Collier and Hubbart, 2001). That is, the major mode is usually related to positive emotions, such as happiness, whereas the minor mode is related to negative emotions, such as sadness. However, the effects may be different for differential background music listening conditions.

In sum, the present results are in line with the findings on the falling and rising movement in infant-directed speech and singing, and bodily and facial expressions. Generally, rising movement might be inherently related to increased arousal and pleasantness, whereas falling movement might be inherently related to decreased arousal and unpleasantness. The present study also demonstrates the importance of studying music as a background for other activities in addition to studying the effects of plain music. The everyday activities and music may be linked in ways not predictable by research on the effects of plain music. In the present study, the foreground music elicited responses related to musical connotations (i.e., major sequences as most pleasant and minor sequences as most unpleasant), whereas background music elicited responses related to the congruency with the stimuli it was combined with (i.e., in connection with negative news, minor mode sequences were rated as most pleasant).

The data in study IV showed that the reading was most efficient in Bach-fast condition and most inefficient in Bach-slow condition. However there was no main effect of music on reading time and efficiency compared to no music. Therefore the Hypothesis 1, which stated that reading against background music with earphones might enhance reading in a distracting environment, was not supported. However, when the two music groups were compared, it was noticed that the music tempo had a significant effect on the reading speed and efficiency. The reading rate and the efficiency decreased when the tempo of the music was slowed down. Thus, the Hypothesis 2, which stated that the subjects in the slow-music condition read slower than the subjects in the fast-music condition, was supported. In connection with affective ratings for the news messages, we also found that, women showed more positive judgments of news in the no-music condition, whereas men showed more positive judgments of news in the slow-music condition.

The results show that the music tempo may have an impact on reading. One reason for why the reading rate and efficiency decreased when the tempo of the music was slowed down may be that in a noisy environment, the clear and accented beat of the Bach music may have anchored the reading process. Another explanation is that different tempo music activates people to different degrees. The slow music may have produced a more relaxed feeling for reading. A more cognitive based explanation would suggest that the slow-music took more effort and memory allocation, which in turn diminished the resources available for reading, because it contains more perceptual units than fast music. This interpretation is based on findings which suggest that events lasting for a few seconds are processed as a whole (perception of duration), but for durations that exceed 3 seconds, memory processes are involved that link the past with the present (estimation of the duration; Wittman and Pöppel, 1999). In the Bach-fast music two measures are close enough (less than 3 seconds) in time to be perceived as one perceptual unit and in the Bach-slow music they are far enough (over 3 seconds) to be perceived as two distinct units.

The reason for the finding why women showed the most positive judgments of news in the no-music condition, whereas men showed the most positive judgments of news in the slow-music condition, is not clear at present. Based on an assumption that positive attitudes are attached to the object that appears with appealing music, as well as Kellaris & Rice's (1993) finding that faster speed produces less negative responses to music in both genders, it would have been expected that men would have judged the news more positively in the fast-music condition, instead of the slow-music condition. One reason could be that women and men applied a different reading strategy on the task; based on reading times which were higher among men than among women, men might have resulted in a more relaxed and involved experience, which in turn shows up in more positive judgments on the news content, whereas women may have applied a more task oriented approach. However, these notions must remain conjectural.

The main focus of the studies III and IV was on the effects of single structural characteristics on music and differential music listening context (i.e., in study III foreground versus background listening, and in study IV, reading news with and without background music). The most notable finding was that background and foreground listening produced very different responses. However, as noted earlier in this thesis, in addition of musical characteristics and context, the individual differences such as personality and musical preferences, may significantly moderate the responses to music. In study II, we found some personality related differences. In study III and IV, we found age and gender related differences. In the studies V, VI, and VII we wanted especially to focus on the personality related differences in responses to music (study V) and reading (study VI), and listening (study VII) to news messages while listening to music.

4.3 Studies V, VI, and VII

4.3.1 Results

In study V, we found that the affect ratings, ECG and EEG were significantly influenced by the music listening session. We found, that the post-music rest period elicited higher positive activation ratings than the pre-music rest period ($p < .05$)). In regard to cardiac activity we found that PTT and IBIs were shorter (higher arousal) during the post-music rest period than during the pre-music rest period ($p < .005$ and $p < .001$). In connection with EEG, the analysis revealed significant main effects for mode (eyes-open, eyes-closed, $p < .001$) and hemisphere (left, right; $p < .001$) in predicting frontal alpha. There was less activation (higher power) during eyes-closed than during eyes-open rest. There was also more relative right frontal activation. In regard to parietal alpha, the analysis revealed a significant Condition x Mode interaction ($p < .05$). Parietal eyes-open alpha activation decreased (power increased) from pre- to post-music rest, while the reverse was true for eyes-closed alpha.

We also found significant personality moderated differences in affect ratings, ECG and EEG. In connection with affect ratings the following interactions were found: Condition x BAS-FS interaction in predicting negative activation ratings ($p < .05$); Condition x BIS ($p < .01$) and Condition x N-Anx ($p < .05$) interactions in predicting valence ratings; and Condition x Sociability interaction in predicting arousal ratings. Negative activation ratings were lower after post-music rest period as compared to pre-music rest period among low BAS-FS scorers, whereas among high BAS-FS scorers there was no difference. In connection with BIS and N-Anx, the post-music rest period elicited higher pleasantness ratings among high BIS and high N-Anx scorers, whereas, among low BIS and N-Anx scorers, there were no differences. In connection with Sociability, the post-music rest period elicited higher arousal ratings than pre-music rest period especially among low Sociability scorers, whereas among high Sociability scorers the reverse was true.

There were also many personality-moderated effects on EEG. There was a significant Condition x BAS-FS interaction in predicting overall alpha power ($p < .05$). Alpha activation increased among low BAS-FS scorers from pre- to post-music rest period, whereas among high BAS-FS scorers the reverse was true. The analysis revealed also a significant Condition x BIS interaction in predicting the overall alpha power ($p < .05$). Alpha activation increased among high BIS scorers, but decreased among low BIS scorers. In connection with parietal alpha, we found significant Condition x BIS ($p < .005$) and Condition x N-Anx ($p < .05$) interactions in predicting the parietal alpha power. Parietal activation increased among high BIS and high N-Anx scorers from pre- to post-music rest, whereas among low BIS and low N-Anx scorers, the opposite was true. When predicting temporal alpha, significant Condition x BAS-FS ($p < .05$) and Condition x Hemisphere x BIS interactions ($p < .05$) were found. Temporal alpha activation increased among low BAS-FS scorers from pre-music to post-music rest, while it decreased among high BAS-FS scorers. In connection with BIS, the higher relative right temporal activation decreased among high BIS scorers from pre- to post-music rest, whereas the reverse was true for low BIS scorers.

A significant Condition x Sociability interaction in predicting theta activation was also revealed ($p < .05$). Theta activation decreased from pre- to post-music rest among low Sociability scorers, but increased among high sociability scorers.

The analysis of the data of study VI revealed significant main effects for type of background music in predicting pleasure ($p = .046$), arousal ($p = .022$), and interest ($p = .040$) ratings for the news stories. Pleasure ratings were lower, but arousal and interest ratings higher for news stories with startling music as compared to those with non-startling music. In addition, there was a significant BAS Reward Responsiveness x Type of Background Music interaction in predicting arousal ratings of news stories ($p = .025$), and a BAS Drive x Type of Background Music interaction in predicting interest ratings ($p = .021$). News stories accompanied by startling music were rated as more arousing than news stories accompanied by non-startling music among low Reward Responsiveness scorers, but not among high Reward Responsiveness scorers.

News stories accompanied by startling music were rated as more interesting than news stories accompanied by non-startling music among high Drive scorers, but not among low Drive scorers.

In connection with psychophysiological responses, a significant main effect for type of background music in predicting NS-SCR freq. (p = .004) was revealed. NS-SCR freq. was higher when reading news stories with startling music as compared to non-startling music. In addition, we found Global BAS x Type of Background Music and BAS Fun Seeking x Type of Background Music interactions for NS-SCR freq. during news reading (ps = .026 and .002). Startling background music prompted a more pronounced increase in NS-SCR freq. among low Global BAS scorers as compared to high Global BAS scorers. This was the case also for BAS Fun Seeking.

In connection with EMG, we found a significant BAS Drive x Type of Background Music interaction in predicting zygomatic EMG activity (p = .039). Individuals scoring high on BAS Drive exhibited pronouncedly high zygomatic EMG activity when reading news stories with startling background music. In connection with RSA, we found a significant BAS Reward Responsiveness x Type of Background Music interaction in predicting RSA (p = .037). Startling background music induced an increase in RSA among high BAS Reward Responsiveness scorers.

The analysis of the data of experiment 2 of study VII, revealed significant Imp × Type of Background Melody interaction in predicting arousal ratings (p = .006), Imp × Type of Background Melody interaction in predicting the ratings for importance of the news for the self (p = .038), and N-Anx × Type of Background Melody interaction in predicting the ratings for understandability of the news (p = .042). Rising melody prompted higher arousal ratings compared to a falling melody among high Imp scorers, but not among low Imp scorers. Subjects scoring high on Imp also considered the rising-melody news as more important for themselves than the falling-melody news, whereas the opposite was true for low Imp scorers. In regard to understandability, subjects scoring low on N-Anx considered the falling-melody news as more understandable than the rising-melody news, while the reverse was true for subjects scoring high on N-Anx.

4.3.2 Discussion

We found several personality moderated differences in self-reported affect ratings, cardiovascular activity, and EEG activity between the pre-music and post-music rest periods in study V. Even though the music listening session included several music pieces that differed in terms of valence and arousal, we predicted that the listening session as a whole would raise general arousal and shift the mood of a listener to a more positive direction. Our hypothesis was supported by self-report and cardiovascular data, whereas the EEG results gave only partial support for our hypothesis. As expected, the affect ratings suggested that positive activation and pleasantness increased, particularly among individuals scoring high on BIS sensitivity and N-Anx (i.e., individuals characterized by neuroticism and anxiety proneness). In addition, self-reported arousal increased during the experiment, particularly among low Sociability scorers. In line with the self-report data, cardiovascular activity (increased heart rate and decreased PTT) indicated increased arousal from pre- to post-music rest condition. Given that (a) BIS sensitivity is connected to introversion, neuroticism, and negative affectivity (e.g., Gray, 1991; Jorm et al., 1999) and (b) Neuroticism-Anxiety is connected to anxiety, tension, and fearfulness (Zuckerman et al., 1993), the results support the previous findings suggesting that music may increase positive mood and arousal and reduce stress and depression especially in depressed and anxious individuals (e.g., Davis and Thaut, 1989; Hanser, 1990; Field at al., 1998; Foster and Valentine, 1998; Lai, 1999).

Our hypothesis that there would be more relative left and overall frontal alpha activation during post-music compared to pre-music rest was not supported. Thus, the results gave no support for the valence theory, according to which frontal asymmetry indexes positive or negative mood and the overall frontal activation (across hemispheres) indexes the arousal level. There was more relative right frontal activation during both pre-music and post-music rest. Because we found no significant condition effects for right hemisphere activation, there was no support for the right hemisphere theory either. It is of importance here that the right hemisphere may play a larger role in other kinds of musical information processing than emotional (see Zatorre, 1985; Zatorre & Halpern, 1993; see also Kallinen, 2003). It should also be recognized, however, that the present study design was clearly not optimal to test the validity of the right hemisphere hypothesis.

We found that left temporal alpha activation increased from pre- to post-music rest among high BIS and N-Anx scorers. Davidson et al. (1990) have previously found relatively greater left temporal activation during happy facial expressions, and relatively greater right temporal activation during disgust facial expressions. Thus, in agreement with the self-report valence data, this finding appears to suggest that the music listening session elicited a more positive emotional state among high BIS and N-Anx scorers. The finding may also suggest the importance of temporal, instead of frontal, lateralization for emotional valence in the context of music. Accordingly, Gottselig (2001) found that the right parieto-temporal cortex may play an important role in perceiving emotion: subjects with right parieto-temporal lesions were impaired in perceiving basic emotions in music.

We also found that the overall (all sites) alpha activation increased from pre- to post-music rest among high BIS and low BAS-FS scorers, while the reverse was true among low BIS and high BAS-FS scorers. In addition, we found that the overall (all sites) theta activation decreased from pre- to post-music rest, especially among low Sociability scorers. As noted above, alpha activation is connected to arousal and attentiveness, whereas theta waves are reflective of a state of "dream-like" inattentiveness (Davidson, Jackson, & Larsen, 2000; Makeig & Jung, 1996). That being so, also this finding might suggest that the music listening session increased the attention and arousal level of at least some listeners.

In study VI, the results revealed several main effects of startling music: news stories with startling music were rated as less pleasant, more arousing, and more interesting, and they also prompted higher physiological arousal as measured by NS-SCR freq. These main effects were qualified by the significant interaction of BAS × Type of Music, however. Dispositional BIS sensitivity appeared to play no significant role here; this is unexpected, given that the BIS has been suggested as being sensitive to novelty and high-intensity stimuli (Corr, Pickering, & Gray, 1995). No effects indicative of response habituation or sensitization were found either.

Our main finding was that, among high BAS (Drive) scorers, news stories with startling background music were rated as more interesting and prompted higher zygomatic EMG activity than news stories with non-startling music. Thus, among individuals with high BAS sensitivity, relatively uninvolving news stories are experienced as more interesting and a more positive emotional state ensues as a result of startling background music, given that zygomatic EMG activity indexes positive emotions (e.g., Lang, Greenwald, Bradley, & Hamm, 1993). This suggestion is also partly supported by the finding that news stories with startling music were rated as less pleasant among low BAS (Reward Responsiveness) scorers, but not among high BAS (Reward Responsiveness) scorers. These findings suggest that high BAS individuals show "approach"-oriented, as opposed to "withdrawal"-oriented, emotional responses during startling background music, given that high BAS sensitivity increases the probability of approach behaviour (Gray, 1991). Recall also that extraverts and high sensation seekers show a tendency to stimulation seeking in order to raise their arousal to the hedonic optimal (see Matthews & Gilliland, 1999; Zuckerman, 1990); Gray's BAS (or impulsivity) dimension is closely aligned with extraversion (rotation of approx. 30°), and high BAS activity underlies the expression of the sensation seeking trait.

We also found that startling background music elicited an increase in RSA among individuals with high BAS (Reward Responsiveness) scores. Gianaros and Quigley (2001) have previously found that moderate intensity pure tone stimuli (75 dB SPL, 1.5 s duration) elicited an increase in RSA; the authors suggested that the stimulus characteristics likely fell on the border between a typical orienting response and a typical defense response.

In sum, the study VI showed that the relationship of startling background music with emotion- and attention-related subjective and physiological responses elicited during reading news reports differed as a function of dispositional BAS sensitivity of an individual. Startling background music elicited negative arousal among low BAS individuals, whereas a positive emotional state and stronger positive engagement ensued among high BAS individuals, although background music had no effect on memory performance. Thus, the present study suggests that a given type of background music may have adverse or beneficial effects depending on dispositional BAS sensitivity of an individual.

In study VII, we found several personality-related differences in people's emotional and attentional responses to news messages with high-arousal (i.e., a fast speech rate or a rising background melody) and low-arousal (i.e., a slow speech rate or a falling background melody) audio characteristics, which were presented using a computer (see also Kallinen & Ravaja, in Press). As expected, the findings were in line with the similarity-attraction principle (cf. Nass & Lee, 2001).

We found that a rising background melody (i.e., a high-arousal stimulus) elicited more arousal among individuals scoring high on the Imp and BAS dimensions. Thus, our hypothesis 1b, which stated that high scorers on the extraversion-related scales would be more aroused during the high-arousal stimuli than during the low-arousal stimuli, was partially supported. The rising-melody news prompted higher arousal ratings especially among high Imp scorers. In addition, the rising melody prompted higher physiological arousal, as measured by NS-SCR freq., than the falling melody among high BAS scorers, whereas the falling-melody news elicited more physiological arousal among low BAS scorers. Given that the Imp and BAS dimensions are related to extraversion (Jorm et al., 1999; Zuckerman et al., 1993), these findings are compatible with psychophysiological studies suggestive of greater arousability of extraverts in high-stimulation environments (see Matthews & Gilliland, 1999).

Our hypothesis 2, which stated that subjects would evaluate also the other properties of the news (e.g., importance and understandability) more favourably when the audio characteristics match their personality traits, was also supported. We found that high N-Anx scorers rated the high-arousal (and tension-eliciting) stimuli (i.e., news with a rising background melody), as being more understandable. It is possible that a rising background melody operates as a signal for high N-Anx scorers that result in increased processing of the stimulus (and in higher perceived understandability). We also found that high Imp scorers rated the rising-melody news as more important for themselves, while the opposite was true for low Imp scorers.

The results also provided some support for the hypothesis 3 stating that subjects would pay more attention to the news when the audio characteristics match their own personality. It was also found that IBIs were longer (i.e., lower HR and increased attention) during the falling-melody news than the rising-melody news among low Agg-Host scorers. Thus, the results suggest that low Agg-Host scorers showed increased attention to low-arousal news messages, although the evidence cannot be regarded as conclusive. The aforementioned findings are also in line with studies showing that individuals preferentially process stimuli that are emotionally congruent with their stable personality traits (i.e., the trait-congruency hypothesis; Rusting, 1998).

In sum, the results of the study VII were largely in agreement with the principle of similarity-attraction; that is, people may be attracted to computer-mediated messages with audio characteristics manifesting emotions or a personality similar to their own. Apparently, even a single audio feature of a complex media message may elicit differential emotional effects depending on the personality of the listener.

In studies V, VI, and VII the focus was on the personality moderated effects in emotional and other responses. We found several consistent and significant effects. Thus these findings are contradictory to some writers who have suggested that personality is the weakest moderator among the factors contributing to emotional responses (see Scherer, Zentner, and Schacht, 2002). These results suggest that personality may be a powerful predictor of emotional responses to music. Thus more research on the personality and other background factors of the listeners should be done.

4.4 General Discussion - Some General Findings

Musical emotion is a multidimensional phenomenon

In sum, the seven studies demonstrate the multidimensional nature of musical emotions. Emotions may be influenced by both cognitive evaluation and changes in the body. We also argued, that musical emotions develop out of the interaction of musical, individual, and contextual factors. Studies I and II showed that people's emotional responses to music are related to the emotional character of the music. Studies III, IV, VI, and VII showed that responses are related to the characteristics of music structure. The fact that a context matters was especially showed in the study III, in which we found differential effects for foreground and background listening. In regard to individual differences, especially studies V, VI, and VII showed that personality dimensions of the listeners may be powerful predictors of the emotional responses to music.

Musical emotions are accompanied by distinct self-report and physiological patters

We found support for both subjective feelings and physiological responses in connection with music. Subjective feelings were often accompanied with distinct physiological patterns, such as raised EDA, or changes in EMG. The findings on physiological measurements contradict the view, which considers the physiological component of emotion too diffuse to be differentiated in different emotions. It has been suggested that because different emotions may consist of the same physiological patterns and because physiological responses may occur without any emotion, it is difficult to make any conclusions on the nature of emotional responses using the physiological data. However, as noted above, our findings contradict these views (see also Kallinen, 2003 and 2004). This was especially true for the results concerning EDA, ECG, and EMG, whereas EEG appeared to give only partial or no information about the emotional responses (see also Kallinen, 2003). In connection with EEG and emotions, it has been noted that the cognitive processing of music may obscure any systematic emotional effects in cerebral asymmetry. Another point is that emotional processing might mainly take place deeper in the brain than cortex (e.g., in limbic system).

In sum, self-report and psychophysiological measurements both give information about the emotional responses but they may be focused on different emotion components: self-report gives information most often about a higher psychological level in the mind, whereas the psychophysiological measures are most often used as indices for "lower" level physiological processes in the body. Typically, but not necessarily, in a full emotional experience both the mind and body is involved in the experience.

Musical emotions are heterogeneous and hierarchical

The results of the study I and II showed that people can be quite consistent in their overall judgments on music. However, there was also much variety in the emotions suggested in the survey and in the judgments in the listening experiments. Therefore, the results suggest (a) that some emotions might be more important than others (hierarchy), and (b) that in addition to a basic set of emotions (e.g., basic emotions or valence and arousal) there exists a variety of different emotions and emotion-like expression, and experiences in music (heterogeneous). It has been suggested (see e.g., Juslin, 1998) that, because of their genetic history and intrinsic relation to emotional expression (e.g., Ekman, 1992), basic emotions (such as joy and sadness) should be easier to communicate and recognize than other emotions (e.g., jealousy). The results suggest that joy and sadness are the most reliably communicated emotions, whereas, in connection with other emotions, the variation in responses increased. It might be interesting for future research to focus also on emotions and emotion-related variables other than the basic emotions and the valence and arousal dimensions. This kind of research might lead to whole new ideas on emotions in music, because emotions in music might be something very different from everyday emotions or emotions directly linked to survival and bell being that play an important role in the models focusing on basic emotions or the valence and arousal dimensions.

Structural characteristics of music may be the most important factor in listeners' judgments on emotional quality of a musical stimulus

Even though we did not study the relative importance of different attributes of musical emotions, the results suggest that the structural characteristics might be the most important factor the listeners' perceptions are based on. In connection with the consensus of the emotional characteristics of the music pieces in the study I, the results raised a question about what aspects of the music the listeners' agreement was based on. In other words, how listeners were able differentiate between sad and joyful music, for example? Given that in the study I the sample was quite large, it is probable that the listener consensus cannot be based on some cultural background information or learned response, but on the characteristics of music itself. Though music may refer to extra-musical phenomena to which the emotional meaning of music may be associated directly and independently of the structural characteristics of music, and even though it should be recognized that the music structure was not the primary focus of the present studies, the results may suggest that the emotional quality of music is often based on the music structural characteristics, such as tonality, tempo, articulation and harmony (see e.g., Juslin, 1998; Gabrielsson and Juslin, 1996). This interpretation is in line with Scherer at als (2002) findings on the weight of different factors that were related to emotions elicited by music. In their survey, musical structure was given the highest rating of the list of potential determinants of musical emotions. We found support for this view also in our studies III, IV, and VI. By manipulating the structural characteristics (contour, tempo, volume) we managed to gain differential emotional responses in listeners (see also Kallinen, in revision). The results suggest that the effects of music structural characteristics on emotions should be studied, or at least controlled, in studies using different music pieces. One reason for equivocal findings in previous music emotion research might be that the structural characteristics of music have been neglected. As pointed out by Alpert & Alpert (1990) and Kellaris & Rice (1993) future research should try to identify the effects of the structural characteristics of music on the observed phenomenon. For example, music listeners might like a sad piece of music more than a joyful piece, not because of emotional connotation, but because of a more interesting structure (e.g., chord progressions).

Music sometimes elicits emotional responses that are predictable

Our hypotheses on the effects of music on emotional responses were often supported. Thus the emotional responses were predictable. For example, in study II we found that perceived and felt emotions were very similar. In study III, as we expected, a rising contour was related to higher arousal and pleasantness. As also expected, the foreground listening elicited responses related to musical connotations. The study V supported the view that in general music has a positive effect on listeners.

Music often arouses emotions similar it expresses, with the exception of negative emotions

Study II especially showed that a positive relationship is the most likely relationship between emotions felt and emotions perceived in music. That is, music aroused very similar emotions that it was evaluated as being expressive of. Of course, given that we studied this only in one of the papers (study II); these findings should be validated in a larger body of studies. We also found that fearful music was perceived as negative but felt as relatively positive. Negative emotions may be more difficult to elicit than positive with music. One reason for this could be that music as an emotional object is different from real life emotional situations, because music does not pose a real threat to people. With music people are able to confront and deal with negative emotions in a safe and positive way. Another reason may be that negative emotions are more seldom directly expressed in the repertoire of western art music people can most often hear in concerts, radios etc. (i.e., Baroque, Classicism, and Romanticism), because music has traditionally been composed for enjoyment, aesthetic pleasure, and practical purposes, such as masses, funerals, and festivals.

The interaction between (background) music and some other stimuli (e.g., reading, pre-existing mood) can usually be explained in terms of mood congruency

According to the mood congruency hypothesis, people preferentially process information that is congruent with their current mood (see e.g., Rusting, 2000). Mood congruency may enhance learning, and memory, but may also have an effect on emotional responses. Stimuli (e.g., music and some other stimuli) may act as primes for associated ideas in the network structure that is organized by similarity and associative proximity in the brain. Materials that are congruent with each other or with the subject's present mood become salient and are more likely to be attended to and deeply processed than noncongruent material (see Bower, 1981; Gilligan & Bower, 1984; Niedenthal et al., 1994). In study III we found that the responses to news messages with background tone sequences appeared to be influenced by both the tone sequences and the emotional tone of the news. In the background tone sequence condition, the minor mode versions that were congruent with the emotional tone of the news (i.e., negative) were evaluated as most pleasant. This result is consistent with the findings showing that congruencies between the different characteristics of stimuli result in more positive responses (e.g., Nass and Lee, 2001).

In study VII, we also found some support for our hypothesis stating that subjects would pay more attention to the news when the audio characteristics match their own personality. We found that IBIs were longer (i.e., lower HR and increased attention) during the falling-melody news (i.e., low-arousal stimuli) than the rising-melody news (i.e., high-arousal stimuli) among low Agg-Host scorers. Given the association of anger with high-arousal (stimuli), it could be expected that high Agg-Host scorers prefer high arousal and low Agg-Host scorers low-arousal stimuli. The results might suggest that low Agg-Host scorers showed increased attention to low-arousal news messages, although the evidence cannot be regarded as conclusive.

In sum, the aforementioned findings are in line with studies showing that individuals preferentially process stimuli that are emotionally congruent with their stable personality traits (i.e., the trait-congruency hypothesis; Rusting, 1998). We also argue that the reason for a more positive evaluation during matching than during mismatching stimuli is because of mood congruency. The two stimuli that are congruent are more easily processed and fire nodes in the brain that store similar information, whereas incongruent stimuli fire nodes containing contrasting information.

The interaction between personality and musical stimuli can usually be explained in terms of similarity-attraction

The principle of similarity-attraction states that people may be attracted to persons who are similar to themselves. Studies on media stimuli have also shown that people evaluate mediated objects more positively when they match their own personality dimensions (Nass and Lee, 2001). We found support for that theory: Study VI showed that among high BAS (Drive) scorers, news stories with startling (i.e., high arousing) background music were rated as more interesting and prompted higher zygomatic EMG activity than news stories with non-startling music (i.e., low arousing). Startling background music also elicited more attention (as indexed with RSA) among individuals with high BAS (Reward Responsiveness) scores. In study VII we also found that a high-arousal stimulus (i.e., rising background melody) elicited more arousal among individuals scoring high on the Imp and BAS dimensions, and that subjects evaluated the properties of the news (e.g., importance and understandability) more favourably when the audio characteristics match their personality traits. In sum, these main findings are compatible with the principle of similarity-attraction.

Music may have beneficial effects especially for introvert and anxiety prone listeners

In regard to personality, we have noticed that especially the traits related to "negative" emotionality (e.g., N-Anx and BIS) have been effective moderators of emotional responses in connection with music. We found in study V, that negative activation ratings were lower after post-music rest period as compared to pre-music rest period among low BAS-FS scorers, whereas among high BAS-FS scorers there was no difference. In connection with BIS and N-Anx, the post-music rest period elicited higher pleasantness ratings among high BIS and high N-Anx scorers, whereas, among low BIS and N-Anx scorers, there were no differences. In connection with Sociability, the post-music rest period elicited higher arousal ratings than pre-music rest period especially among low Sociability scorers, whereas among high Sociability scorers the reverse was true. We also found that the overall (all sites) alpha activation increased from pre- to post-music rest among high BIS and low BAS-FS scorers, while the reverse was true among low BIS and high BAS-FS scorers, thus suggesting that the attention or arousal level increased among high BIS and low BAS-FS scorers but decreased among low BIS and high BAS-FS scorers. Thus, in sum, the results support the previous findings that suggest that music may increase positive mood and arousal and reduce stress and depression especially in depressed and anxious individuals (e.g., Davis and Thaut, 1989; Hanser, 1990; Field at al., 1998; Foster and Valentine, 1998; Lai, 1999), given that BIS sensitivity is connected to introversion, neuroticism, and negative affectivity and Neuroticism-Anxiety is connected to anxiety, tension, and fearfulness. However, the results may also suggest that even though music may have beneficial effects especially among introvert people, individuals characterized by neurotic behaviour and anxiety tend to evaluate stimuli as more emotional, but may nevertheless be unable to engage emotionally with them owing to their high inhibitory tendencies. This conclusion was based on the findings in study II. We found that (a) the difference between perceived and felt arousal was higher among high BIS and high N-ANX scorers than among low BIS and low N-ANX scorers and (b) the difference between perceived and felt PA was higher among high BIS than among low BIS scorers.

In regard to the personality-related differences in responses, it should be acknowledged that there may also be other than the BIS/BAS and Zuckerman's alternative five personality dimensions that might have a moderating effect in music listening. These models were chosen because they both are psychobiological models of personality, and thus particularly relevant, given that we were interested in psychophysiological responses, among other things. In addition to the finding showing that music may have beneficial effects especially for introvert and anxiety-prone listeners, music may also be beneficial in connection with more positive personality dimensions, such as openness to experience or ability get absorbed in music. For example, we recently found that high self-transcendence (ST; see Cloninger, Svrakic, and Przybeck, 1993) scorers were more involved in listening to music than low ST scorers (Kallinen, Saari, Ravaja, and Laarni, 2005). Thus, future research might include also other personality models, such as the spiritual/intellectual dimensions, relevant for understanding individual differences in responses to music.

The multidimensional research method produces more precise information on musical emotions than the traditional methods

It has been suggested, that the equivocal findings of research on the emotional effects of music might result from the fact that the components of musical emotions have not been sufficiently understood nor controlled. In sum, the multidimensional research approach seems to produce many interesting, and presumably more precise, results on emotional effects of music, because the effects of various components of emotions can be examined and controlled.

Multidimensional method contributes to a more comprehensive view on musical emotions

We argued that emotions are processes that consist of various interactive components, such as musical attributes, individual attributes, and contextual attributes. We have proposed a multidimensional research approach, because it consists of measuring subjective responses as well as psychophysiological responses in examining the role of different components of emotions. Therefore by combining the information on different measures, manipulations, and context it is possible to go one step closer to a more comprehensive theory of musical emotions.

5 CONCLUSIONS

Music has usually been treated as a quite uniform entity in the studies on the emotion-related effects of music. However, because the complex nature of the interaction between music, context, and the individual, the same music may give rise to a number of different kinds of emotional effects. In addition, even a single piece of music may be loaded with ambiguous emotional expressions, because it's rich structure.

In the present study, we proposed a multidimensional research approach, that consists of subjective responses, psychophysiological responses, and various traits in research settings designed to examine the relationships between the musical, individual, and contextual attributes that may influence emotions. In a series of studies, we used very similar methods, the focus was in one way or another on the three attributes (musical, individual, or contextual) that may influence the emotional effects of music, and the results were interpreted from the point of view of a comprehensive theory of musical emotions. In general, studies I and II focused on the emotional quality and effects of music per se. Studies III and IV focused more on the (multimodal) context of music, whereas in studies V, VI, and VII we focused especially on the individual differences in emotional responses to music.

This study showed that various factors related to music per se, as well as listener and context characteristics, exert an influence on the emotional reactions. The results suggest that the combination of physiological and psychological measures used in this study may be a promising way to get more detailed information about the listeners' responses to music.

However, it should be acknowledged that the present studies left many questions open in regard to the factors of musical emotions. For example, we provided little evidence for the process model of emotion, even though in many of the studies we did examine the physiological data over smaller time units during the stimuli. However, generally we did not find order effects other than an orienting response in the beginning of the stimuli in these analyses. One reason can be the kind of stimuli we used. Musical materials were most typically chosen to express a certain emotion at a time, not a process from one emotion to another, for example. Another restriction and possible focus of research in the future is the social context and the listeners or musicians interactions in musical emotions. We acknowledge that these factors may in some cases be very powerful elicitors and moderators of emotions.

It should also be acknowledged that more research is needed to understand the functions of different components of musical emotions. Future work should especially focus on examining the relationships between the different measures, for example, by comparing the results on the function of central nervous system and autonomic nervous system.

YHTEENVETO

KOHTI KOKONAISVALTAISTA TEORIAA MUSIIKILLISISTA EMOOTIOISTA

Moniulotteinen tutkimuslähestymistapa ja empiirisiä havaintoja

Tutkimuksessa tarkasteltiin musiikin kuuntelun eri osatekijöiden vaikutuksia musiikin tai siihen liitetyn muun ärsykkeen kokemiseen. Teoreettisena viitekehyksenä oli musiikillisten emootioiden määritteleminen prosesseiksi, jotka muodostuvat musiikin ominaisuuksien (esimerkiksi tempo ja harmonia), musiikkia kuuntelevan yksilön ominaisuuksien (esimerkiksi persoonallisuus ja musiikkimaku), sekä musiikin kuuntelun sosiaalisen (esimerkiksi konsertti, jumppatunti) tai muun (esimerkiksi multimedia) kontekstin vuorovaikutuksesta jonain aikana ja jossain tilassa. Aikaisempien musiikin emotionaalista kokemusta koskevien tutkimusten ristiriitaisten tutkimustulosten yksi keskeinen syy saattaa olla se, että emotionaalisen kokemisen eri mekanismeja ja komponentteja ei ole riittävän hyvin tunnettu ja kontrolloitu.

Kehitimme tätä tutkimussarjaa varten ns. moniulotteisen tutkimuslähestymistavan, jossa emotionaaliseen kokemukseen vaikuttavia eri osatekijöitä voidaan tarkastella ja kontrolloida entistä paremmin. Moniulotteinen lähestymistapa sisältää (a) mittareita, joilla voidaan tarkastella sekä tietoisia kognitiivisia responsseja (emotionaalisten responssien itseraportointi esimerkiksi lomakkeilla) ja mahdollisesti osittain tiedostamattomia psykofysiologisia responsseja (mm. aivojen sähköinen toiminta, kasvonlihasten aktiviteetti, sydämen sähköine toiminta, sekä ihon sähkönjohtavuus), sekä mittareita, joilla voidaan tarkastella yksilöllisiä ja kontekstin tuottamia eroja (esimerkiksi persoonallisuuspiirremittarit), ja (b) tutkimusasetelmia, joissa tarkastellaan emootion eri osatekijöiden (musiikki, yksilö, konteksti) suhdetta (esimerkiksi muuntelemalla musiikin rakennepiirteitä).

Tutkimustulokset osoittivat muun muassa sen, että musiikki on moniulotteinen ilmiö ja että musiikilliset emootiot ovat moninaisia, mutta mahdollisesti hierarkkisesti järjestäytyneitä. Tulokset osoittivat myös sen, että musiikin vaikutukset ovat usein hyvin ennustettavia ja että musiikki saa kuulijoissaan usein aikaan samanlaisia tuntemuksia (koettu emootio), kuin mitä se periaatteessa myös ilmaisee (ilmaistu emootio), vaikka edellä mainitut eivät aina olekaan yhdenmukaisia. Esimerkiksi surulliseksi arvioidut musiikkikappaleet arvioitiin negatiivisiksi mutta koettiin positiivisiksi. Emotionaalisissa responsseissa oli myös paljon yksilöllisiä ja kontekstista johtuvia eroja, jotka selittyivät mm. persoonallisuuserojen ja kahden eri ärsykkeen (esimerkiksi taustamusiikin ja tekstimuotoisen uutisen) emotionaalisen yhteneväisyyden perusteella. Yleisesti persoonallisuuden ja musiikin suhde noudatti ns. samankaltaisuus – vetovoima periaatetta (similarity – attraction principle), jonka mukaan ihmisiä miellyttää ja vetää puoleensa sellainen musiikki (tai muu media-ärsyke) tai toinen ihminen, jonka persoonallisuus vastaa tai jonka ominaisuudet kuvastavat henkilön omaa persoonallisuutta tai ominaisuuksia. Yleisesti ottaen taustamusiikin ja jonkin toisen ärsykkeen (esimerkiksi luettava uutinen) suhde noudatti ns. tunnekongruenssi periaatetta, jonka mukaan ihmiset prosessoivat mieluiten sellaista tietoa ja kokevat sellaisen media-ärsykkeen miellyttäväksi, jossa tiedon eri osatekijät ovat yhteensopivia joko keskenään tai henkilön oman tunnetilan kanssa.

Yhteenvetona voidaan todeta, että moniulotteinen tutkimuslähestymistapa tuottaa mielenkiintoista ja entistä tarkempaa tutkimustietoa musiikin emotionaalisista vaikutuksista ja siinä vaikuttavien osatekijöiden suhteista. Tutkimustieto auttaa luomaan entistä yhtenäisemmän kuvan musiikillisista emootioista. Lisää tutkimusta kuitenkin tarvitaan esimerkiksi eri mittareiden tuottamien tulosten yhteensopivuudesta ja emootioissa vaikuttavista dynaamisista prosesseista.

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