Music Influences Listeners' Emotion – A Review on Evidence From Psychological and Physiological Research

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The paper presents a review on emotional processes involved in music listening. First a theoretical perspective on emotion is introduced, the appraisal-centered approach. Next to that, detailed account to theories explaining emotion in music is given. There, the following topics are addressed: differences between emotion felt and perceived, strong emotions evoked by music (so-called Chills), and social influences on emotion. Also different models explaining various mechanisms involved in musically induced emotion are discussed. Finally the review presents an overview on the different methods included in emotional research on music. There, evidence from studies using psychological and physiological measurements of emotion will be outlined.

Der Artikel präsentiert eine Literaturübersicht zu emotionalen Prozessen, die im Zusammenhang mit dem Musikhören stehen. Als Erstes wird eine appraisal-zentrierte Emotionstheorie vorgestellt. Im Anschluss daran werden ausführlich Theorien erläutert die emotionale Reaktionen auf Musik erklären. Dabei werden die folgenden Themen betrachtet: Unterschiede zwischen in der Musik erkannten und gefühlten Emotionen, starke durch Musik evozierte Emotionen (sogenannte Chills) und soziale Einflüsse auf Emotionen. Dabei werden auch Modelle diskutiert, die verschiedene an der Entstehung von Emotionen im Zusammenhang mit Musik beteiligte Mechanismen erklären. Schließlich präsentiert der Artikel einen Überblick zu den unterschiedlichen Methoden, die zur Emotionsforschung hinsichtlich von Musik verwendet werden. Dabei wird Evidenz von Studien, die psychologische und physiologische Messungen des emotionalen Erlebens verwendeten, betrachtet.

Introduction

When the stadium clock read 9:37 Paul Drew introduced ‚The Beatles' who suddenly appeared from the third base dug out and sprinted to the stage. The crowd erupted into one continuous earth-shaking scream and the stands lit up with camera flashes that sparkled like fireworks. A Beatles stadium concert didn't need a light show or special effects; instead there was the awe-inspiring spectacle of their fervent audience. The Beatles plugged in and launched into their hit ‚Twist and Shout' followed immediately by ‚She's A Woman'. As Paul began to introduce their third number, he stopped apparently amazed that he could hear his own

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voice and commented ‚It's loud isn't it? …Great!' Over the last two years of Beatle mania, the band had grown accustomed to being drowned out by their audience and could rarely hear their own music.

Description of the 1965 Beatles concert in Atlanta Stadium on their nine-city North American tour (Thompson, 2003), 10

This quotation impressively illustrates how the fans of the Beatles were moved during their concerts: Sometimes they were screaming so loudly that the musicians couldn't hear themselves. Screaming is the vocal expression of a very intense emotion (Peretz, 2001). You scream when you are surprised, you fear something, or even sometimes when you want to express enthusiasm. But why were the audiences of the Beatles' concerts so emotionally affected that their screams were „earth-shaking"?

On the one hand, they were very close to their idols and couldn't wait to see them live. But on the other hand, it might also have been the music performed, which led them to these ecstatic responses. Emotional responses to music are a very common phenomenon because music surrounds us everywhere: at home, at work, in cars, in restaurants, at shopping centers – or when making music ourselves. Juslin, Liljeström, Västfjäll, Barradas, and Silva (2008) confirmed this omnipresence of music in everyday life by using the experience sampling method: In 37% of all examined episodes, participants listened to music. One of the most important reasons for listening to music is its effect on emotions. In 64% of the music episodes investigated by Juslin et al., participants reported that the music influenced how they felt. But how can it be that such a stimulus is so effective in influencing our feelings? How can it be that music is emotional?

To answer these questions, many different experimental studies have been conducted. Music has repeatedly been shown to induce pleasurable emotional responses, including ecstatic *chill* and *thrill* experiences, which are accompanied by shivers down the spine or goose bumps (Goldstein, 1980; Sloboda, 1991; Panksepp, 1995). Explanations for these emotional effects were often related to the qualities of the music (such as the compositional structures, performance features, and acoustic parameters) or to the listener himself.

However, past studies primarily concentrated on the experience of socially isolated individuals; the interpersonal influences on emotional induction through music were not in the focus of previous research – despite the many social aspects of music in everyday life (North & Hargreaves, 2008). The neglect of the interpersonal influences on emotion is consistent with the general psychological theory of emotion: Emotions are generally regarded as consequences of a cognitive appraisal process (Scherer, 2004; Scherer, 2005), and social influences on this appraisal have been rarely investigated (Manstead, 2005). It seems very plausible, however, that the emotional expressions emitted by the Beatles' audiences might have been the result of an interaction of social and music factors. Social relations existed between the fans and the musicians who were communicating emotional expressions in their

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music and among the fans themselves who were possibly emotionally contagioned by each other due to reacting emotionally to the music.

The following review will try to give an overview on theories and research related to music and emotion. Doing so, different approaches to this topic will be presented, including the difference between felt and perceived emotions, strong emotions, the influence of emotions on memory for music, and finally research on social influences. Additionally different methods for emotion research on music will be discussed, including implications for future research.

Theoretical Perspectives on Emotion

The term *emotion* originates from the Latin *e-movere*, which can be translated as *move out and away* or *interrupt* (Sokolowski, 2002). Unfortunately, the disciplines involved in the investigation of emotions have not been able to agree up to now on a uniform definition of emotions. Sloboda and Juslin (2005, p. 770) comment on this fact with a citation of Fehr and Russell (1982): „Everybody knows what an emotion is, until asked to give a definition." Here Sloboda and Juslin allude to the fact that emotion is both an everyday phenomenon and a scientific construct. Everyday theories of emotion often combine different phenomena, which should be carefully distinguished (Scherer, 2005): For example, emotions are different from moods due to their shorter duration, distinct object focus, and higher intensity. There are also ongoing controversies related to the question of what affective feelings and emotions induced by music really are (for a review see Juslin & Västfjäll, 2008). Thus for scientific research, a precise definition is needed.

In the studies from my research group, emotion is used according to the *component process model* presented by Scherer (2004; 2005). According to this model, an emotional episode is triggered by a cognitive evaluation process (appraisal component) and consists of coordinated changes in four major reaction components: physiological arousal, motivational component, motor expression, and subjective feelings. Table 1 shows the different functions of all components and localizes their organismic substrata. Changes in these components may be highly synchronized to adapt optimally to the eliciting circumstances. Furthermore, Scherer distinguishes between *utilitarian* and *aesthetic* emotions, which differ in appraisal concerning goal relevance. The absence of direct personal relevance in aesthetic emotions leads to rather diffuse, reactive physiological, and behavioral changes in contrast to distinct and proactive changes in the case of utilitarian emotions, including so-called *basic emotions* (Ekman & Davidson, 1994; Scherer, 2004).

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Emotion function	Organismic subsystem and major substrata	Emotion component
Evaluation of objects and events	Information processing (CNS)	Cognitive component (appraisal)
System regulation	Support (CNS, NES, ANS)	Neurophysiological component (bodily symptoms)
Preparation and directions of action	Executive (CNS)	Motivational component (action tendencies)
Communication of reaction and behavioral intention	Action (SNS)	Motor expression component (facial and vocal expression)
Monitoring of internal state and organism-environment interaction	Monitor (CNS)	Subjective feeling component (emotional experience)

Table 1. Relationships Between Organismic Subsystems and the Functions and Components of Emotion (Scherer, 2005). (Note. CNS = central nervous system; NES = neuro-endocrine system; ANS = autonomic nervous system; SNS = somatic nervous system.)

Physiological Bases of Emotion

According to Iversen, Kupfermann, and Kandel (2000), emotions are the result of an interplay of higher (e. g. the cingulate or orbitofrontal cortex) and lower brain centers, such as the sub-cortical regions hypothalamus and amygdala. Together these structures form the *limbic system* (Panksepp, 1998). The sub-cortical centers integrate autonomic and endocrine responses. Thus autonomic activations can be indicators of emotional reactions. They prepare the body for adaptive behaviors – for example, the *fight-or-flight* response. The peripheral vegetative nervous system can be separated into two parts (Jänig, 2000): The sympathetic part is active during arousal, suspense, and stress. The opposite, parasympathetic part is active during relaxation and prepares for food intake and digestion. Besides other functions, sympathetic arousal leads to increased blood pressure, heart rate, and blood circulation in the muscles. In the skin the sympathetic nervous system also innervates the sweat glands and the piloerector muscles (Iversen et al., 2000), leading to an erection of the skin's hair. This phenomenon is also often described as „goose bumps," occurring during the sensation of coldness or very intense emotional reactions. The parasympathetic nervous system antagonizes the sympathetic nervous system by decreasing heart rate and increasing the blood flow in digestion organs, for example.

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Music and Emotion

Music has often been shown to affect mood and emotion (Scherer & Zentner, 2001; Juslin & Västfjäll, 2008). Effects on mood are characterized as rather long-lasting tonic affective states, while the emotions that originate in connection with music are perceived as brief episodic changes of these states (Sloboda & Juslin, 2001). For example, a study of Schramm (2005) examined how music is used in daily life to regulate moods. He was able to show that listening to music is sometimes used to strengthen certain moods and sometimes to compensate others. Some music listeners try in such a way to attenuate negative moods; others want to maintain them (e. g., a melancholy) by listening to music. In certain music styles, rather short changing emotion episodes are in the foreground. These can change from moment to moment. It is also possible that within a piece of music, conflict-like and contrary emotional expressions coincide (Sloboda & Juslin, 2005). This can lead to the experience of music as an emotional roller coaster. Memory for music was also shown to be better for emotional music compared to less emotional music. In an experimental study investigating episodic memory for 40 excerpts of film music, it was shown that music rated as very positive was better recognized compared to music that was rated as less positive (Eschrich, Münte, & Altenmüller, 2008).

Differences between emotion felt and perceived

According to Gabrielsson (2002), there is a difference between perceived and felt emotions in music. Music is able to express a certain emotional expression. But this emotional expression is not also induced in every listener automatically. For example, a sad song does not always make every listener feel sad, even if the listener perceives and recognizes the sad emotional expression in the piece. Gabrielsson describes four different relations between the types of emotion in music:

- In a positive relation, the emotion expressed is also felt by the listener. For example, a piece is composed and performed as „happy“ and also elicits a „happy“ response in the listener.
- The negative relation describes the opposite phenomenon. The piece's contrary emotion is induced in the listener. For example a piece composed and performed as „happy“ elicits a „sad“ response in the listener.
- In a non-systematic relation, the emotion expressed elicits either no emotion in the listener or a different emotion from the one expressed.
- When there is no relationship, an emotion is induced in the listener although there was no emotional expression in the music.

Kallinen and Ravaja (2006) investigated empirically the relations between emotion felt and perceived in music listening. Thirty-two participants rated emotions induced and perceived in 12 pieces of classical music. Their main result was that in general, emotion perceived was rated higher compared to induced emotions. For positive emotions a positive relationship was observed, but for negative emotions a negative relationship occurred. The authors also reported that individual differences

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in the relations between felt and perceived emotions could be partially explained by different personality traits. Thus it is important to distinguish between the two different types of emotion in music. In experimental research, participants should always be clearly instructed to rate the one or the other.

Theories explaining musically induced emotion

Scherer and Zentner (2001) presented a hypothetical formalization of the process by which music generates emotion. They formulated a multiplicative function consisting of several factors, thereby distinguishing between several input variables and one output variable (the experienced emotion):

> Experienced emotion = Structural features x Performance features x Listener features x Contextual features, where
> Structural features = W1 (Segmental features) x W2 (Suprasegmental features),
> Performance features = W3 (Performer skills) x W4 (Performer state),
> Listener features = W5 (Musical expertise) x W6 (Stable dispositions) x W7 (Current motivational/mood state), and
> Contextual features = W8 (Location) x W9 (Event). (p. 365)

They chose a multiplicative rather than an additive function because they assumed that any of the factors in the absence of the other factors could lead to reliable emotional reactions. Additionally, they noted that the factors interact with each other (e. g., listener features might interact with structural features), and supposed that the factors carry different weights (W1 to W9).

Segmental structural features consist of the single tones' acoustic characteristics, such as duration, amplitude, pitch, and spectral composition of the complex wave (timbre). Suprasegmental features are described as „changes in sound sequences over time“ (p. 364). They include melody, tempo, rhythm, harmony, and other formal and structural features. The authors assume that here emotional information is expressed via *iconic coding* (depicting external non-musical objects) and *symbolic coding* (cultural learned meanings of musical expressions). Performance features might have an emotional impact via the performers' skills, appearance, reputation, and expression as well as interpretation, concentration, and mood (states). Scherer and Zentner categorize musical expertise (knowledge of musical systems), personality, listening habits, and also motivational and mood states as listener features. Finally, contextual features consist of the location of music listening and the occasion of listening (e. g., wedding, funeral, celebration).

In addition to these features, Scherer and Zentner (2001) describe different *production rules*, explaining the emotion induction mechanisms behind such variables. Juslin and Västfjäll (2008) also present a similar list of mechanisms and discuss empirical evidence for each one of them:

1. Cognitive appraisal: This mechanism elicits emotion by appraisal of the music with regard to the goals of a music listener (also described by Scherer & Zentner, 2001).

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2. Brain stem reflexes: According to the authors, brainstem reflexes occur when, for example, a sudden increase in loudness in the music provokes a startle response in the listener.
3. Visual imagery: Furthermore, visual imagery induces emotion during music listening when mental images are evoked by the music.
4. Evaluative conditioning: This mechanism refers to an unconditioned positive or negative stimulus that is paired with the music and affects the emotional response to it.
5. Musical expectancy: Music is also able to affect emotions by violating or confirming listeners' expectations – a mechanism described by Meyer already in 1956.
6. Episodic memory: This mechanism is active when past emotional events are remembered along with the music (also described by Scherer & Zentner, 2001).
7. Emotional contagion: Here, emotion is induced by internally mimicking the emotional expression of the music (also described by Scherer & Zentner, 2001).

Juslin and Västfjäll (2008) and Scherer and Zentner (2001) agree on the fact that music induces emotions. But they disagree on whether music induces real world emotions experienced in every day life. Scherer (2004) argues that compared to other stimuli, music has no meaning for survival and thus only induces aesthetic emotions, with which not all emotion components are always synchronized. Also Konečni (2008) disputes that music induces real emotions, he rather proposes new feeling concepts, like *being moved* or *aesthetic awe* induced by music. In contrast, Juslin and Västfjäll cite different studies each proving that music affects one of the different emotion components. For a complete proof of the hypothesis that music induces real basic emotions with synchronized emotion components, multiple components would have to be measured synchronously.

Strong emotions induced by music

There has been much research dedicated to the understanding of strong emotions in music. Gabrielsson and Lindström Wik (1993; 2003) investigated *strong experiences with music* (SEM) by conducting qualitative interviews and asking for very emotional events that occurred while listening to music. One of the most pleasurable emotional events that can be experienced is a chill (Sloboda, 1991; Panksepp, 1995) or thrill (Goldstein, 1980). These reactions are frequently accompanied by measurable physiological reactions, such as changes in skin conductance and in heart and breathing rate (Grewe, Nagel, Kopiez, & Altenmüller, in press). Goldstein (1980) studied the effect of an opiate antagonist on the duration, frequency, and intensity of thrills and found that thrills may be attenuated by naloxone. Not all participants were susceptible to thrills: 10% of the music students, 20% of the medical students, and 47% of the employees of a research center responded that they had never experienced thrills. Sloboda (1991) investigated this phenomenon by using questionnaires to collect reports of participants' strongest emotional reactions to music over the five years prior to the study. The questionnaires included items

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about physiological reactions (such as chills, tears, laughter, etc.) and examined the relationship between the occurrence of such experiences and musical parameters. His analyses showed that there do seem to be musical events related to these experiences; for example, chills appear to coincide with new and/or unprepared harmonies as well as with sudden dynamic or textural changes.

Does this imply that those pleasurable chills people experience when listening to music are only a physiological reaction to a certain abrupt change in the acoustic stimulus? If so, everyone should experience chills when listening to music that contains the musical events necessary to stimulate chills. Yet this is not the case – music preference is highly individual (Blood & Zatorre, 2001). The results of Grewe, Nagel, Kopiez, and Altenmüller (2007b) support the claim that chills are not automatic reflex-like responses; there were no musical structures that induced chills across most participants. Rather, it seems likely that „a cognitive, implicit evaluation triggered by attention-raising structures leads to an emotional process and a chill occurs in the context of this process" (Grewe et al., 2007b, p. 312). One of the songs in Grewe et al.'s study („Making love out of nothing at all" by Air Supply) was also played in Panksepp's (1995) experiment but with differing results. Grewe et al. found a much lower occurrence of chills during this piece, a finding for which there could be many reasons: for instance, a different generation of music listeners in the latter study or – more importantly – the fact that Panksepp tested his participants sitting together in a room. Hence they might have been socially influenced during music listening.

Individual differences in musically induced emotion

Grewe et al. (2007b) examined whether different personality characters are related to the experience of chills. It was observed that high chill-responders score lower on the personality trait sensation seeking (Litle & Zuckermann, 1986). In addition, the high chill-responders were stronger reward-dependent (Cloninger, Przybeck, Svrakic, & Wetzel, 1999) compared with the participants experiencing fewer chills. Kreutz, Ott, Teichmann, Osawa, and Vaitl (2008) also showed that individual differences in induced emotions by classical music relate to a personality trait. Music listeners scoring high on absorption rated the music to be more activating and emotionally intense. Another parameter influencing the intensity as well as arousal and valence ratings was the preference for classical music. Contrary to the authors' hypotheses, participants with more musical skills had no stronger emotions during music listening compared with those less skilled – except in activation ratings.

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Social Influences on Musically Induced Emotion

Scherer and Zentner (2001) noted that musically induced emotions might be influenced by the audience in a concert setting:

> We submit that all these features can have an influence on the acoustics, the ambiance of the location, or the behavior of the audience, which in turn may lead to different emotional effects due to objective features of the situation or subjective perceptions of the listeners (p. 365).

It seems plausible for them to conclude that the location of the concert affects the behavior of people and this, in turn, affects emotion. Other researchers have also discussed social aspects of emotion. According to Manstead (2005), emotions are social for three reasons: First, emotions refer to objects that can often be social; one example of objects is music as a „social and cultural artifact" (p. 485). Second, many emotions are functionally social, such as love, shame, embarrassment, or sympathy, and their predominant function is to increase social coherence. Third, Manstead emphasizes the human capacity and need for social sharing of experienced emotion. This is most powerfully reflected in the many instances when we feel empathy.

Many of the mechanisms described by Juslin and Västfjäll (2008) could be socially influenced. In evaluative conditioning, the unconditioned stimulus can be social – for example the good friend, with whom one repeatedly goes to concerts. Thus the conditioned response (the music in the concert) will be socially affected. Emotional contagion also has a social dimension. Often the emotional expression is attributed to a musician or composer, and the music itself has voice-like perceptual characteristics (the *super expressive voice theory* of Juslin & Västfjäll, 2008). But also observing somebody else's emotional reactions to music can lead to emotional contagion on the side of the listener. Episodic memory can be related to social aspects as well when a past social event, such as the loss of a loved one, is remembered with the music. Furthermore, cognitive appraisal might be socially affected. The social dimension of this aspect will be discussed in the next section.

Theoretical perspectives on social aspects of emotion

The above-mentioned appraisal theory of emotion states that emotions emerge from a cognitive evaluation of the emotion inducing events on the dimensions novelty, urgency, coping potential, norm compatibility, and goal congruence (Juslin & Västfjäll, 2008). I assume that this evaluation process can be influenced by social feedback because norms are socially determined, and being socially accepted is one very important human goal (Brehm, Kassin, & Fein, 1999). For example, Fischer, Rotteveel, Every, and Manstead (2004) showed that participants are affected by the emotions of others, confirming the emotional assimilation hypothesis. Manstead and Fischer (2001) suggested that appraisals are often influenced by social experiences, a phenomenon they call *social appraisal*. This happens in two different ways: In one, another person is part of the emotional event appraised (e. g., being insulted

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by someone leads to social appraisal, because the insult from another person is appraised); in the other, social appraisal occurs when we observe another person's reactions to an emotional event. In this case, the person is not part of the emotional event, but still has an influence on our appraisal. This type of social appraisal shapes one's perception of emotional situations, making it possible for other people to be involved in the construction of appraisal. Such a process is exemplified by a male watching a sexist comedy in the company of a female friend; her presence might influence the male's amusement, leading to different emotions than if he had been watching the film with other males or alone (Manstead & Fischer, 2001).

Another theory that includes social aspects in the explanation of emotion is the *social facilitation theory*, which predicts that the mere presence of others leads to increased arousal (Zajonc, 1965). Because of this increased arousal, dominant (already-learned) responses occur more frequently, and the learning of new responses is impaired. Zajonc explains this connection through the attainment of an optimal or too-high arousal level, which in turn depends on the task that participants are requested to complete. Causes of this group-induced arousal can be (a) generally increased attention; (b) the fear of being evaluated by others; or (c) a distraction by the group (Aronson, Wilson, & Akert, 2004). However, social situations do not always lead to social facilitation; rather, the opposite phenomenon, *social loafing*, has been observed. The latter refers to the situation in which group members cannot accurately evaluate the performance of their peers (Aronson et al., 2004). Under such circumstances, individuals have no fear of being evaluated and relax, leading to a state of decreased arousal, which in turn improves performance on difficult tasks. In sum, social situations could lead to increased or decreased arousal during music listening, depending on the amount of social control the music listeners have over each other.

Social feedback can produce a tendency towards social conformity. Two forms of conformity are described in the literature (Brehm et al., 1999; Cialdini & Goldstein, 2004): *informational influence* describes conforming to others due to having insufficient information about an object to evaluate and thus having to rely on others' judgments. Already in 1936, Sherif showed that the movement rating of a light point (that objectively didn't move at all but, because of the autokinetic effect, seemed to) is affected by social feedback. The informational influence described by Sherif can also lead to private acceptance, meaning that one privately believes in the other's feedback one is conforming to. The other form is called *normative influence*, occurring when people follow group norms in order to be included in the group. Some of the most prominent studies on normative conformity were the experiments by Asch (1955). He showed that participants were affected by normative social feedback when asked to judge the length of simple lines, leading them to give wrong answers. This form of social influence often leads to public compliance only, without changing one's attitude or perception. It has also been shown that individual differences in social conformity exist. Klein (1972) presented data confirming that older people show more conformity than younger, especially

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when tasks are difficult. He could find no gender differences, although in other studies it was often reported that females behave more socially conformal than males (Aronson et al., 2004).

Research on social influences on music

Due to the dearth of research on the effect of social influences in music-related topics (for a review see Crozier, 1997; North & Hargreaves, 2008) social facilitation and other influences have rarely been investigated in this context (North & Hargreaves, 2008). But Davidson (1997) acknowledges that social facilitation might occur often: For example, for performers through the presence of an audience at a concert. She reports an anecdote about the famous singer Caruso who claimed he could only sing his top C convincingly if he had an audience.

In a Web-based study, Salganik, Dodds, and Watts (2006) asked participants to choose songs to download. In the experimental condition, feedback regarding the frequency of peer downloads was varied. As a result, popular songs (as indicated by feedback) were downloaded more often than less popular songs, suggesting that music listeners tend to base their aesthetic choices not only on the quality of music, but also on the behavior of others.

Radocy (1975) used confederates to ascertain whether other people could influence participants' perception judgments. The participating students were asked to match pairs of simple tones differing in loudness or pitch, and complied with the confederates in 30 % (pitch ratings) and 49 % (loudness ratings) of trials when incorrect social feedback was given. He also reported that greater conformity was observed in the loudness-discrimination task when the discrepancy between the confederates' judgments and the correct response was small. Thus plausible feedback manipulations were more effective than implausible.

Like Aebischer, Hewstone, and Henderson (1984), Furman and Duke (1988) investigated preferences of music listeners and found that ratings of unfamiliar orchestral music were affected by social feedback, but this did not occur with familiar pop music. Furman and Duke also explored whether music majors would diverge from non-majors and reported that no differences between those two groups were found in the socially biased condition. In summary, the results of previous research suggest that both music listening and emotion are subject to social influences.

In a Web-based study, Egermann, Grewe, Kopiez and Altenmüller (2009) tried to combine two areas of research: social influences on music listening and emotion rating. They investigated whether the emotional effects of music could be manipulated by social feedback. More than 5,000 participants listened to 5 randomly chosen music excerpts (out of a total of 23 excerpts). After each excerpt, they rated induced emotions according to arousal and valence dimensions. Participants were randomly assigned to two groups. In contrast to group 1 (control group), participants in group 2 (experimental group) received feedback allegedly based on the emotional ratings of preceding participants. In actual fact, the feedback presented to participants was based on the upper or lower quartiles of a pretest

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rating. Based on this feedback manipulation, some excerpts were classified as higher in arousal and valence, and some excerpts were classified as lower on those dimensions compared with the ratings of the unbiased control group. Results show that the manipulated feedback significantly influenced participants' ratings in group 2 in the direction manipulated compared with those in group 1 without feedback. It was concluded that musically induced emotions might be socially influenced. Another study investigated whether listening to music in a group setting influences the emotion felt by listeners (Sutherland, Grewe, Egermann, Nagel, Kopiez & Altenmüller, 2009). The emotional reactions to 10 musical excerpts were measured both psychologically (button presses indicated the experience of a chill) and physiologically (skin conductance response) using a new, innovative multi-channel measuring device. The 14 participants (7 male, 7 female; mean age 29 years) came in for two testing sessions: once alone, and once as a group. Results indicated that the number of chills did not differ significantly between the 2 conditions (alone and group), but that there was a trend for experiencing more chills in the alone listening session. This and other results suggested that music listening was more arousing alone, possibly due to the lack of social feedback in the group setting.

Methods to Measure Musically Induced Emotion

The emotional experience during music listening can be determined in many different ways. In previous research every single emotion component was measured (Juslin & Västfjäll, 2008). Physiological processes can be recorded from the peripheral autonomous and the central nervous system. Emotional behavior has also been recorded while participants listened to music. The subjective experience (subjective feeling) was investigated using different emotion models and rating methods. Different methods to quantify all three emotion components will now be described in detail.

Emotion models for the subjective feeling component

To measure the subjective feeling component of emotion, three different approaches were developed: adjective lists, categorical emotion models, and dimensional emotion models.

Adjective lists. With the help of different adjectives that verbally label emotional feelings, the subjective component has been examined. For example, Krumhansl (1997) used 13 adjectives to grasp participants' experiences during music listening. Hevner (1936) also assembled an adjective list in order to catch the rich diversity of emotional feelings. But while such a method of providing adjective lists has advantages, it also has one major disadvantage, namely, the researcher's self-defined emotional labels inhibits the comparability of different studies using different lists. The reliability of every new list used might further be reduced.

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Categorical emotion models. According to the categorical approach, emotions are experienced as distinguishable categories (Sloboda & Juslin, 2005). These categories form so-called fundamental basic emotions, which are innate and universal and had a behavior adapting function in the evolution of humans. Most emotion researchers agree on the fact that at least five basic emotions exist: happiness, sadness, anger, fear and disgust (Sloboda & Juslin, 2001). The facial expressions of those emotions were shown to be culturally independent (Ekman & Davidson, 1994). Some theorists disagree that music induces basic emotions, such as anger and fear, which are similar to everyday life emotions (Scherer, 2004).

Dimensional emotion models. Already in 1897 Wundt maintained that the different states of feeling consist of three bipolar partial feelings (Sloboda & Juslin, 2001; Sokolowski, 2002). According to Wundt, these three bipolar partial feelings are called desire/listlessness, excitement/relaxation, and tension/solution (Sokolowski, 2002). Feeling dimensions were also derived by Russell (1980) with the help of factor analyses and multidimensional scalings from different emotional terms. Russell identified a small number of dimensions as valence and arousal. With the help of these two dimensions, all terms examined by Russell could be projected onto a circle structure model with two orthogonal axes (see Figure 1). The bipolar dimension valence was placed along the horizontal axis, from negative = unpleasant (on the left) to positive = pleasant (on the right). Russell drew the dimension arousal vertically from low = calming (on the bottom) to high = arousing (on the top).

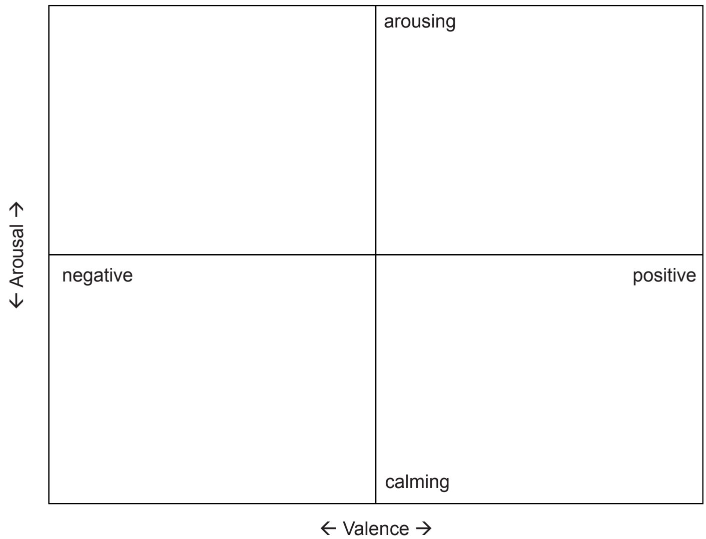

Figure 1. The emotions space based on the circumplex model of affects (Russell, 1980). The dimension valence is presented on the horizontal axis and the dimension arousal on the vertical axis.

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Other emotion researchers described also a third dimension called *potence* going from strong to weak. The attempts at defining dimensions have been criticized because these models distinguish some feelings insufficiently: Emotions like fear and anger correlate within the two-dimensional model highly with each other and are positioned on the same place in the co-ordinate system. In any case, for musically induced emotions similar dimensions were found using factor analyses and multidimensional scalings (Krumhansl, 1997; Bigand, Vieillard, Madurell, Marozeau, & Dacquet, 2005). Both the categorical and dimensional attempts at classifying emotions are considered by many researchers to be mutual supplements, and both approaches are supported by neurophysiological data (Sloboda & Juslin, 2005).

Continuous vs. retrospectively ratings

Ratings of subjective feelings during music listening can be provided continuously during music listening or retrospectively after music listening:

Continuous ratings have the advantage that the dynamics of emotions in music listening can be measured, because for every point in the time course of the stimulus, ratings are recorded. Additionally, this method requires less memory performance from the participants, because emotions felt during listening don't have to be memorized during listening and afterwards reported. The disadvantages of this method are that only a maximum of two dimensions can be measured at the same time and that the rating apparatus might require too much technical effort. Already in 1936 Hevner examined discretely (at different time points) the emotional effect of certain compositional structures (e. g. major vs. minor) while participants listened to selected pieces. With the help of adjectives, participants had to rate the music's effect on them during the breaks between single parts of a composition. In addition, musical stimuli were re-arranged to achieve a variation of conditions for single parameters to be examined. The study is of historical value because it was the first attempt to measure emotion in music continuously. Other music researchers have used newly developed computer methods that allowed simultaneous and continuous report of the dynamics of emotional processes during music listening. Schubert (1998; 1999, 2001, 2004) used the two-dimensional emotion space, which is based on the dimensional emotion model of Russell (1980). The participants had to indicate the emotions expressed in the music by mouse movements on the arousal and valence dimensions in the emotion space. Thus ratings on two dimensions could be performed simultaneously. In this way, Schubert wanted to investigate the temporal-dynamic processes of musically emotional events. It was of interest how structural and acoustic patterns influence the perception of emotions in music across time. With different re-test studies and the fulfillment of various criteria, Schubert (1999) showed that the emotion space is a reliable and valid instrument. Nagel, Kopiez, Grewe, and Altenmüller (2007) proposed a new method for recording and measuring continuously self-reported emotions. In order to grasp the subjective experience of motions, Nagel et al. measured the two-dimensional emotion space based on Schubert (1999) using the *EMuJoy* software. But with the

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mouse movements in Nagel et al.'s study, the participants were not to indicate the affect expressed in the music, but rather the dynamics of their own emotional state. Therefore, they used the dimensions valence and arousal and could indicate chills by clicking the mouse button. Thus participants provided an emotional self-report of three parameters in parallel.

In contrast to continuous ratings, retrospective ratings also have advantages: First, many different rating dimensions can be sampled from the participants. Also, the technical effort needed to realize this measurement is smaller compared with continuous ratings. Simple paper-and-pencil questionnaires suffice. But the disadvantages are that dynamic processes cannot be measured with them and that they also rely on the participants' memory capacity.

The decision whether to use continuous or retrospective ratings should be based on the focus of interest. If the focus is on the temporal aspects of emotion in complete music pieces, one should refer to continuous measurements. If it is rather on effects of single music excerpts, retrospective ratings are adequate. Using only music excerpts yields also the advantage that the stimulus set of a study can be much bigger than when using whole pieces.

Physiological and behavioral measurements of emotion

Physiological activations can be indicators of emotional experiences, and there are several parameters of the peripheral nervous system that can be measured. The *Electro Dermal Activity* (EDA) is being divided into two signals: The *Skin Conductance Level* (SCL) is primarily based on sweating reactions and changes in blood flow (Boucsein, 2001). These reactions have been widely used as indicators of psychological reactivity, especially as indicators of arousal, orienting responses, and startle responses. *Skin Conductance Response* (SCR) reflects the changes in SCL over a short period, and is therefore adapted to measure reactions to affective musical events. The *Heart Rate* (HR) can also be measured and indicates, similar to the *Breathing Rate* (BR), physiological excitement.

In addition to recording subjective experiences using the EMuJoy software, Grewe et al. (2007b) measured different physiological parameters while hearing music. By doing so, the researchers tried to measure musically induced emotional reactions at different components simultaneously. Both signals of skin conductance, BR and the HR, were recorded in parallel. Using this set-up, they could observe relations between chills and the HR's variability as well as SCR. But their results reveal that it was not possible to differentiate between certain experienced emotions with physiological measurements. Therefore, with this method it is only possible to validate the psychological self-report about the subjective experience. Nevertheless, measuring chills seems to be a promising approach to measure musically induced emotion, because chills combine reactions in two emotion components (the subjective feeling and the physiological component, Grewe et al., in press).

Behavioral changes by emotions in connection with music were also examined by Grewe et al. (2007b), who monitored activations of certain facial muscles using

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Electromyography (EMG). These were associated with certain expressions of basic emotions (Ekman & Davidson, 1994). Grewe et al. supposed that different muscles stand in connection with different valence and arousal states. However, no statistically significant muscle reactions connected with emotional experiences could be found.

Also, the central nervous system was investigated in relation to music and emotion. Investigations of cerebral activations of emotions during music listening were carried out with different methods, such as Electroencephalography (EEG), the functional Magnetic Resonance Imaging (fMRI), or the Positron Emission Tomography (PET).

Altenmüller, Schürmann, Lim, and Parlitz (2002) showed that positive emotions expressed by music pieces lead to a higher activation in the left hemisphere compared with a higher activation in the right hemisphere caused by negative valenced music (using EEG). These findings support the valence hypothesis of emotion, stating that differences in valence are reflected by different cortical lateralization patterns (Peretz, 2001). Goydke, Altenmüller, Müller, and Münte (2004) also investigated emotion employing EEG, but they used only single tones, differing in timbre, reflecting differences in emotional expression. They could show that a mismatch negativity is evoked by changes in this emotional expression. Another investigation reported the activation of deep sub-cortical brain structures while participants listened to very pleasant and emotional intensifying music (Blood & Zatorre, 2001). Here PET was used, and participants brought their own music to the experiment in order to increase the occurrence of strong emotions. Kreutz, Russ, Bongard, and Lanfermann (2003) did research on cerebral correlates of music listening, but they used fMRI. In their study it was shown that happy classical music leads to distinct cortical activations, compared with sad music. The contrast happy vs. sad showed a bilateral significant cluster in the temporal poles.

Online Web experiments for music and emotion research

In measuring the subjective feeling component of emotion, Web experiments might be a promising way to advance Nagel et al.'s (2007) method. According to Reips (2002), Web experiments have many useful advantages over conventional lab studies: A high number of participants can be reached because of easy access to the experiment (i.e., by bringing the experiment to the participants rather than the participants to the experiment). A large sample meets requirements of rating the very subjective and individually varying emotional feelings during music listening (Grewe, Nagel, Kopiez, & Altenmüller, 2007a). There are no time constraints for participation and they permit the implementation of a high standardization. There are no direct social interactions and because of this there is less researcher bias affecting participants. For instance, it could be that due to demand effects (e. g. the researcher's expectations to have emotions), participants in a lab setting rate intensity of emotions higher than they would in a Web-based setting. Participation takes place in a more natural environment (thus enabling a bigger external validity, also

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due to a higher realistic variance in many parameters on the side of the participants, Honing & Ladinig, 2008; Honing & Reips, 2008). A familiar, non-artificial setting could be important for measuring subjective experiences of emotions. They allow an open research process in which external people can control others' methods. Reips also mentioned some disadvantages of Web experiments: They offer less control than do lab experiments and technical problems may arise on the participant's end. However, Reips (2002) also gave some hints as to how to eliminate these potential problems. For instance, he suggested using the high hurdle technique to control the dropout rate and motivational problems. This can be accomplished by including a warm-up section, which participants have to pass in order to reach the main section. Thus insufficiently motivated participants will drop out in the warm-up and not in the main section, leaving only motivated participants in the dataset.

To my knowledge, only three of the studies using Web-based methods have been published in journals (Marcell & Falls, 2001; Honing, 2006; Salganik et al., 2006). The small number of studies shows that the method of the Web experimenting has not yet been fully established in music psychology and related disciplines up to now, even though modern computer users are equipped with broadband Internet access and high-quality sound cards. These technical prerequisites generate many interesting applications of this new method. The following citation by Musch and Reips (2000) illustrates the considerable potential of Internet research: „Although computerized experiments have become the method of choice in conducting psychological research, there are many signs that another revolution is now beginning. It is associated with the recent exponential growth of the Internet" (p. 62).

The aim of the study of Egermann, Nagel, Kopiez and Altenmüller (in revision) was to explore the possibilities of an innovative Internet-based method for the measurement of emotional music experiences. Eighty-three participants listened to different music pieces. At the same time they gave a continuous self-report about their emotional state by moving their computer-mouse in a two-dimensional emotion space and indicating chills (strong emotions accompanied by shivers down the spine or goose pimples) by clicking the mouse button. The emotional dimensions assessed were arousal and valence. Participants reported that the music pieces caused different emotional reactions that were not significantly different from a lab study using the same stimuli. Thus the validity of this Internet-based method could be confirmed. In general, nearly all participants evaluated positively most aspects of the study – with the exception of the participation time. None of the technical parameters investigated at the participants' computers significantly affected the emotional self-report, but an influence of the self-rated concentration on arousal and chill ratings was observed. The results show that experiments in the Web offer a promising way for emotion research.

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Conclusions and Implications

For the measurement of emotional responses to music, the following conclusions can be drawn form the studies discussed in this review:

The results of Sutherland, et al. (2009) indicated that there were no significant differences in the subjective feeling component between two conditions (listening alone and in a group). To measure this emotion component, an adjective list was taken, similar to that of Krumhansl (1997). In Sutherland et al.'s study, many of the emotion-related adjectives seemed not to appear at all during the two conditions. It is possible that in this list emotions not inducible by music were included, and thus no differences between the subjective feelings for the two conditions were measured. The individual medians were very low, especially for all negative emotions. This raises the questions, which emotions can be induced by music at all, and how they might be measured.

These questions are not easy to answer, since there is no commonly accepted definition of emotion (Sloboda & Juslin, 2001). For instance, Panksepp (1998) describes the neuronal bases of different basic emotions and defines *seeking* as one of them, because it has been identified as a distinct neuronal emotion system. This contradicts other lists of basic emotions, which exclude seeking (Sokolowski, 2002). Scherer (2005) describes emotions as synchronized responses to cognitive appraisal processes, and others regard them as psychobehavioral tendencies to respond to environmental challenges in the mammalian brain (Panksepp, 1998). Thus every theorist has a different perspective on emotion. Scherer focuses on higher and more complex human emotions, whereas Panksepp explains the emotional phenomena that are less complex and also found in other species. In other words, the two researchers use the same word for two different things. The differentiation between higher and lower emotional processing was also confirmed by the research of LeDoux (Sokolowski, 2002). It was shown that there are two ways of emotion induction. The low road runs subcortical from the thalamus directly to the amygdala. This center computes a fast and simple stimulus evaluation that can lead to endocrine, visceral, and behavioral responses: The freezing or startle response to threatening stimuli is realized like this. The high road runs from the thalamus via the orbitofrontal cortex to the amygdala. This mechanism is slower than the low road, but more precise in analyzing the stimulus. In this way, higher appraisals concerning goal congruency and coping potential are included in the emotional processing.

Finding the ideal method to measure emotional responses to music is also difficult because there is no generally accepted model to measure the subjective feeling component of musically induced emotion. Some scholars do not accept basic emotional models, because they claim that music does not induce basic emotions, but rather aesthetic emotions that are not always accompanied by physiological responses (Scherer, 2004). The dimensional models have also been criticized because they do not differentiate some emotions (e. g., anger and fear). The bipolarity of the valence dimension has been questioned as well. Hunter, Schellenberg, and

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Schimmack (2008) showed that music with contradicting emotional cues was able to elicit happy and sad feelings at the same time (mixed feelings). To solve these controversies regarding the measurement of musically induced emotion, Zentner, Grandjean, and Scherer (2008) developed a new emotion model for measuring music specific emotions. The *Geneva Emotional Music Scale* was derived in four experiments by surveying participants about verbal labels of musically induced feelings. By doing so, the authors identified a nine-factorial structure mapping emotional responses specific to music. The authors admitted that their model might only be applied to the effects of music styles used in their studies, and some feelings might still be missing. Nevertheless, using this method might be an appropriate way to grasp the subjective experiences during music listening.

Another promising approach to measure fully synchronized emotional responses to music could be the chill reaction. Recent research (Grewe et al., in press) has shown the chill reaction to be accompanied by measurable physiological correlates (SCRs). Ideally, this measurement of the autonomous nervous system could be an objective measure of emotion. It would not be affected by answering biases and could measure real emotions, activating all components. But it is not possible to draw conclusions about emotional processes only from physiological data (Grewe et al., 2007b). The autonomous nervous system is not only activated during emotional events, but also during orienting responses or controlling visceral functions. As follows, autonomous reactions always have to be validated by the measurement of subjective feelings. But are chills really such an ideal parameter to measure emotional responses to music? They might not be because in Sutherland et al.'s study (2009) they were very rare. One participant didn't report any chills at all. Also the chill rate in Grewe et al.'s (2007b) was very small, similar to Goldstein's (1980) experiment. Thus chills might be used as indicators of strong emotions, but always additional measures should be included to measure emotional reactions to music. Using Zentner et al.'s (2008) emotion model could be appropriate for retrospective emotion ratings, and the dimensional model of Russell (1980) could be used for continuous ratings. The problem concerning mixed feelings like melancholy could then be solved, by defining valence as unpleasant vs. pleasant – and not as sad vs. happy. A melancholic, sad feeling could then be rated as positive and pleasant.

The two emotion models (Zentner et al.'s and Russell's) could also be used in Web-based settings. This would allow continuous or retrospective measurement of musically induced emotions by thousands of participants. This increases the generalizability of the results and possibly clarifies some of the theoretical discourses that have just been discussed. However, the studies of Egermann et al. (in revision, 2009) are some of the first to explore the opportunities of this new method. Their results convincingly indicate that the Internet-based approach was valid in measuring the phenomena investigated. To counteract the experimenter's lack of control over the data collection situation, strict quality criteria had to be fulfilled by the participants. They had to pass a comprehension test, were asked how seriously they were planning to participate, and had to rate their concentration

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at the end. It can't be completely ruled out that a few participants gave untruthful answers, but because of the big sample size, this would not influence the data systematically. Despite the many advantages of Web experimenting,

This method is still not fully accepted in music related research. It is seldom used and also seldom discussed in the methodological literature. By offering insights into its many possible applications, these studies might be a first step to establish this new method. Using this and other methods enables to explain many of the emotional phenomena experienced when listening to music in every day life, offering at the same time a deeper understanding of the human mind in general.

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