How music creates emotion: a multifactorial process approach

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1. Introduction

As demonstrated by many of the chapters in this book, the intimate connections between emotions and music have multiple facets that have fascinated musicians, scientists, and music listeners since the dawn of times. There are two major ways in which music and emotion are related. First, music *represents* (iconically, indexically, or symbolically; Peirce 1867) emotion. This is why music is often called the "language of emotion", referring to the causal effect of emotion on music in the sense that composers integrate emotional elements into their scores, interpreters imbue their performances with emotional qualities, and listeners attribute emotional meaning to different parts of a piece of music. Second, music *creates* real, felt emotions. Here music plays a causal role in producing a specific mental and bodily process in the listener that is commonly called emotion.

A large corpus of literature has consistently reported that listeners often agree rather strongly about what type of emotion is expressed in a particular piece or even in particular moments or sections, thus forcefully suggesting the aptitude of music to convey emotional meaning (see reviews in Gabrielsson & Juslin 1996; Juslin & Laukka 2003; Juslin & Sloboda 2010). However, the perception of emotion in music is fundamentally a sensory and cognitive process that does not necessarily mirror what a listener is actually feeling. For instance, one does not necessarily become sad while listening to a sad-sounding music piece. Indeed, emotions perceived (or expressed by the music) and felt by listeners' may differ, and there is evidence that the relationships between perceived and felt emotions are manifold (Gabrielsson 2002). Whereas the emotions expressed in a piece of music seems to rely mostly on the arrangement of acoustic and musical features (Gabrielsson & Lindström 2010), the emotions experienced by listeners can be triggered by, and are a collective function of, many parameters, including the mood and psychological state of the listener, memories and other previous listening experiences, environmental and other situational aspects, individual preferences and attitudes, cultural conventions, among others (Scherer & Zentner 2001).

In this chapter we primarily address the issue of *emotion induction*, exploring how music produces emotions in the listeners, and identifying the major factors or determinants involved. In addressing these issues we first have to clarify what exactly an emotion is, as this is by no means universally agreed. Hence, we will first provide our view of what is a current

convergence on this definitional issue. We will then explore the possibility that emotions may come in many forms rather than constitute a homogeneous type of human reaction. Here, we will propose that there may indeed be different types of affective reactions of which true emotions are only one manifestation and that even among those emotions there may be different types that are more or less conducive to musical elicitation. Then, we will propose an integrated framework that links the perception and cognition of music (and other associated objects and events) to the production of emotion by means of psychobiological pathways (*routes*) recruiting various subsystems of the central and autonomous nervous systems. We will show that this theoretical framework describes the nature and substrate of a wide range of emotional experiences with music considering a variety of possible modulatory effects. We will also suggest that certain emotional experiences with music are emergent routes in our framework.

2. What is an emotion?

William James posed that question in 1884 and started a debate that is still ongoing. There is a plethora of definitions that have been proposed over the years and it almost seems as though every researcher is intent upon producing his or her own (see Scherer 2005). Here we adopt a position that represents a convergence on some of the major constitutive elements that seem required in order to diagnose the presence of an emotion.

Frijda and Scherer (2009) have summarized the constitutive features of a definition of emotion that seem to be shared by a majority of emotion theorists and researchers in different disciplines: 1) Emotions are elicited when something relevant happens to the organism, having a direct bearing on its needs, goals, values, and general well-being. Relevance is determined by the appraisal of events on a number of criteria, in particular the novelty or unexpectedness of a stimulus or event, its intrinsic pleasantness or unpleasantness, and its motivational consistency, i.e., its conduciveness to satisfy a need, reach a goal, or uphold a value, or its 'obstructiveness' to achieving any of those (Ellsworth & Scherer 2003; Scherer 2001). 2) Emotions prepare the organism to deal with important events in their lives and thus have a strong motivational force, producing states of action readiness (Frijda 2007). 3) Emotions engage the entire person urging action and/or imposing action suspension and are consequently accompanied by preparatory tuning of the somatovisceral and motor systems. This means that emotions involve several components, subsystems of the organism that tend to cohere to a certain degree in emotion episodes, sometimes to the point of becoming highly

synchronized (Scherer 2004, 2005). 4) Emotions bestow control precedence (Frijda 2007) on those states of action readiness, in the sense of claiming (not always successfully) priority in the control of behaviour and experience.

These elements of an emotion definition are also constitutive for emotion episodes as described by the Component Process Model of emotion (CPM; Scherer 1984, 2001, 2009). The CPM focuses on the dynamic unfolding of an emotion in which emotion is defined as a "bounded episode in the life of an individual that is characterized as an emergent pattern of synchronization between changing states of different subsystems of the organism (the components of the emotion), preparing adaptive action tendencies to relevant events as defined by their behavioral meaning (as determined by recurrent appraisal processes) and thus having a powerful impact on behavior and experience" (see Scherer 2005, 2009). Figure 1 shows a graphic representation of the model in terms of the most important recursive causal relationships between the components.

-- Insert Figure 1 about here --

The CPM suggests that an event and its consequences are appraised through a set of criteria (the appraisal components). This does not necessarily require a complex cognitive assessment, and can also occur in an automatic, unconscious, and effortless fashion. Leventhal and Scherer (1987) have suggested that the type of processing with respect to content (types of appraisal) and the level of processing (sensory-motor, schematic, and conceptual) is determined by the need to arrive at a conclusive evaluation result. The result of the appraisal will generally have a motivational effect, often changing or modifying the motivational state that existed before the event occurred. Based on the appraisal results and the simultaneous changes in motivation, there will be effects in the autonomic nervous system (e.g. in the form of cardiovascular and respiratory changes) and in the somatic nervous system (in the form of motor expression in face, voice, and body). All of these components—appraisal results, action tendencies, somatovisceral changes, and motor expressions—are centrally represented and constantly fused in a multimodal integration area (with continuous updating as events and appraisals change).

Parts of this centrally integrated representation may then become conscious and subject to assignment to fuzzy emotion categories which may then lead to the labeling with emotion

words, expressions, or metaphors. The feeling component could also be instrumental in language and music since it allows the organism to regulate and adjust its communication depending on its own emotional experience, which in turn can reflect that of others. For this to occur subjective experience needs to integrate and centrally represent all information about the continuous patterns of change of the components and their coherence with other components, especially if it is to serve a monitoring function.

-- Insert Figure 2 about here --

Figure 2 shows a Venn diagram in which a set of overlapping circles represents the different aspects of feeling.

The first circle (A) represents the sheer reflection or representation of changes in all synchronized components in some form of monitoring structure in the central nervous system (CNS). The second circle (B), which only partially overlaps with the first, represents that part of the integrated central representation that becomes conscious. This circle corresponds most directly to what is more generally called "feelings" or *qualia*. The first author has suggested that the degree of synchronization of the components (which might in turn be determined by the pertinence of the event as appraised by the organism) generates awareness (Scherer 2004; see also Grandjean et al. 2008). Circle C represents the categorization and verbalization (labeling) of feelings (for example in social sharing of emotional experiences).

Past definitions of emotion, as well as the CPM model of the emotion process described above, tend to emphasize the adaptive reactions to relevant events, often stressing physical survival and well-being, as in the case of 'basic emotions'. To be able to describe certain musical experiences as emotional, we need to broaden this definition and consider emotions as adaptations at various levels with different types of relevance, as determined by goals such as experiencing pleasure, regulating arousal, or engaging in social bonding. Such a broader definition of the functions and response patterns of emotion is entirely compatible with the CPM and most other componential emotion theories. For the sake of ecological validity, we must first identify the types of emotional experiences that pertain to music, because it is fundamental to understand these in order to interpret musical emotions, relate them to psychophysiological processes, and integrate them within a general framework emotion.

3. The types of emotion elicited by music

In much of the literature it is been tacitly assumed that music elicits the general set of garden variety of basic emotions. Recently, Juslin and Västfjäll (2008) have attempted to lend credence to this belief by arguing that music-evoked emotions are indistinguishable from other emotions in both their nature and underlying mechanisms and that music just induces some emotions more frequently than others. Several of the discussants of their article (Madison 2008; Moors & Kuppens 2008; Robinson 2008; Malmgren 2008; Scherer & Zentner 2008; Vuust & Frith 2008) have taken issue with this claim. The central problem is that the mechanisms involved in emotion elicitation are ubiquitous, and that many phenomena are produced by an interaction of multiple determinants, and by different mechanisms at different times. In consequence, the fact that some mechanisms are shared by different emotion manifestations cannot be interpreted to mean that all of these belong to the same class. To use a concrete example from another domain, the fact that printing presses are used to produce books, magazines, and newspapers does not mean that all these products are indistinguishable because the production process is comparable.

In trying to disentangle the types of emotional experiences conveyed by music, it is fundamental to start by considering the potential differences between different kinds of affect. To this end, Scherer (2005) has suggested using design feature analysis (Hockett 1960) to distinguish different types of affective phenomena: preferences, emotions, moods, interpersonal stances, attitudes, and personality traits. The design features used to distinguish these different classes of affective states are based on the constitutive elements of the CPM (described in the previous section). Table 1 (adapted from Table 2 in Scherer 2005) shows the proposed classification of the different states based on the extent to which the relative importance of certain design features are constitutive to label an affective state by the respective term.

-- Insert Table 1 here --

It should be noted in passing that music can be expected to elicit simple preference responses (e.g., like or not like the music), moods (e.g., music inducing a pensive mood), or interpersonal stances (e.g., music inducing tender feelings toward others). These effects will not be discussed here; rather, we focus on emotional responses, and particularly on the three subclasses shown in Table 1—utilitarian, aesthetic, and epistemic emotions.

Utilitarian emotions are most often studied in emotion research—for example the 'basic emotions' of anger, fear disgust, and sadness. These are utilitarian in the sense of having major functions in the adaptation and adjustment of individuals to events that have important consequences for their physical survival and well-being by preparing action tendencies (fight, flight) and recovery and reorientation (grief work). But emotions can also serve many other important functions such as social bonding (joy, compassion), enhancement of motivation (pleasure, pride), social obligations and reparation (shame or guilt), among others. Such utilitarian emotions tend to engender relatively high-intensity reactions, often involving a synchronization of many subsystems, including changes in the endocrine, hormonal and autonomous nervous systems as well as in the somatic nervous system, which are driven by the appraisals in the central nervous system. Some of these utilitarian emotions can also be elicited or modulated through music, such as communal singing and dancing, preparation for fighting, or ritual purposes (see Lewis, in press).

We suggest that a major difference between utilitarian emotions on the one hand and aesthetic and epistemic emotions on the other is the fact that appraisals concerning goal relevance and coping potential involve different criteria (such as different goals and coping mechanisms) in aesthetic or epistemic emotions as compared to utilitarian ones. In other words, an aesthetic or epistemic emotional experience is not triggered by concerns with the immediate relevance of an event for one's survival or well-being, nor with how well one can cope with the situation. Rather, the appreciation of the intrinsic qualities of a piece of visual art or a piece of music or the degree of discovery or insight one achieves through novel and complex stimulation in different modalities is of paramount importance. This corresponds in many ways to Kant's well-known definition of aesthetic experience as "interesseloses Wohlgefallen" (disinterested pleasure; Kant 1790, 2001), a definition which insists on the need for a complete absence of utilitarian considerations.

The apparent absence of direct personal relevance in aesthetic or epistemic emotions does not mean that they are completely disembodied. Indeed, we know that music (but also other forms of art) produces physiological and behavioral changes (see Hodges 2010; Västfjäll 2010, for reviews). It should be emphasized though that these changes typically seem to serve behavioral readiness (Frijda 1986) particularly with respect to attention, sharpening of sensory perception, and arousal regulation (stimulation vs. relaxation) rather than fight/flight

reactions. Thus they are not proactive, but rather diffusely reactive. For example, the most commonly reported bodily symptoms for intense aesthetic experiences are goose pimples, shivers, tinkling on the spine, or moist eyes—all rather diffuse responses which do not serve any obvious adaptive purposes, which contrast strongly with the arousal and action-oriented responses for many basic emotions that prepare for emergency reactions.

Following this rationale, our group has empirically studied with which frequency different emotion words indexing the different categories are reported by music listeners. Based on extensive empirical work (identifying which labels listeners to different kinds of music prefer to use to refer to their emotional experiences) we have demonstrated the need for a domain-specific approach to assessing emotional experiences and have developed and validated the Geneva Emotional Music Scale (GEMS), consisting of nine scales: Wonder, Transcendence, Tenderness, Nostalgia, Peacefulness, Power, Joyful activation, Tension, and Sadness (Zentner et al.2008). In a study in which listeners evaluated their emotional reactions to a set of standard musical stimuli in the laboratory and in a free listening task in their homes, using basic emotion scales, dimensional ratings and the GEMS, we could show that the listeners preferred the GEMS scale, that they agreed more on their judgments on the GEMS scale, and that the GEMS ratings more successfully discriminated the musical excerpts. There is now copious empirical evidence that the listening to music is likely to generate more frequently and more consistently the type of emotions, many of which can be glossed as aesthetic, in comparison to that of basic emotions (see Zentner & Eerola 2010; Sloboda 2010) and current studies using the GEMS consistently support the underlying rationale (e.g., Miu & Baltes 2012, Trost et al. 2011).

We continue to develop appropriate measurement tools based on the notion of domain-specific emotion labels, particularly short forms of the GEMS (see Zentner & Eerola 2010, p. 206) that can be used economically in different field settings. It is important to note that even though Zentner et al. (2008) could show satisfactory validity of the GEMS for several music genres (specifically classical, jazz, rock, and pop music in different contexts), we cannot assume that the nine scales of the GEMS exhaust all relevant dimensions. For example, using a short form of the GEMS at a festival for contemporary music (which originally contained nine categories corresponding to the GEMS scales with three adjectives each), we found that it was essential to add scales covering the domain of the epistemic emotions as listener often added labels, such as “feelings of interest and discovery” or “insight”, in the space provided

for additional comments following the regular scale. We concluded that one needs to include more epistemic knowledge and insight related emotions to study the emotional effect of music and we are currently developing a new, expanded rating instrument to be used in naturalistic settings (Coutinho & Scherer 2012).

The effort of distinguishing between different classes of affective states, and further identifying different types of emotion, does not imply that we postulate sharp and reliable boundaries between these classes. On the contrary, we expect that there are very fuzzy boundaries and we have to consider this domain as consisting of a multi-dimensional space rather than one of sharply defined categories. In addition, the meaning of the respective emotion words for the respective classes (see Table 1) are difficult to define and are multiply interrelated (see Fontaine, Scherer, & Soriano, in press, on the semantics of emotion terms). We also acknowledge that music can produce various types of emotions. Nevertheless, as past work in this area has almost exclusively focused on a small set of basic emotions (applied indiscriminately in music studies), we highlight here the preponderance of those emotions that are aesthetic (and also epistemic) in character (i.e., in cases where appreciation of intrinsic qualities is a determining factor). Aesthetic and epistemic emotion responses to music are in urgent need of further examination, because it is fundamental to understand the nature of the wide variety of emotional responses to music in order to establish music's relevance for the individual and assert its power to elicit emotions. We do not exclude however that music may in certain circumstances produce utilitarian emotions. Music might produce sadness, fear, and anger in certain cases. However, one cannot be sure that these have the same quality as sadness, fear, and anger being produced by the loss a loved one, a bear coming towards us, or being insulted. Also, we do not consider that aesthetic emotions are limited to music (they are equally found in the visual and dramatic arts). In fact, there is empirical evidence that emotions relating to nostalgia, love, wonder, and transcendence are experienced equally often in nonmusical everyday life contexts compared with music contexts (Zentner et al. 2008, p. 515).

4. From musical experiences to emotion: A functional account

We now turn to the process of emotion elicitation in the listener. Our starting point is Scherer's and Zentner's (2001) effort to identify the *production rules* that underlie the emotion induction through music, arguing that generally there is an interaction between a multitude of factors in the production of emotional effect distinguishing structural (e.g., tones,

intervals, chords, melodies, fugues), performance (e.g., physical appearance, expression, technical and interpretative skills, current affective and motivational state), listener (e.g., musical expertise, stable dispositions, current motivational and mood state), and context (e.g., location and event) features. It is suggested that these features can, individually or in combination, produce the different affective states described above, assuming a multiplicative interaction function between features, such as: *Experienced Emotion = Effect of Structural features x Performance features x Listener features x Contextual features* (see Scherer & Zentner 2001, for further detail).

Our group conducted a study with music experts (Scherer et al. 2002) examining the relative importance of some of these determinants and the potentially underlying production rules for both classical and non-classical music. Musical structure was given the highest rating of the list of determinants based on the production rules, but technical, acoustical, and interpretational features also received high ratings (see Table 2). It is interesting to note that the experts mentioned many other factors, like listener personality or motivation, that could not subsumed to one of the above classes and show up as "Other" in the table, demonstrating the need to extend the model.

-- Insert Table 2 about here --

In the following sections we will develop this model further. We divide our presentation into three main parts. First we will discuss the role of music structure in emotion elicitation. Then we will identify relevant aspects related to the listening context and briefly exemplify how they modulate and sometimes determine the emotional experience. Finally, we will identify and describe the main routes (and mechanisms involved) whereby emotions may actually be produced by music. It should be stressed that due to space restrictions we will mainly focus on contemporary music activities, such as concerts and individual listening, with a strong emphasis on music as a means to achieve some sort of emotional experience. Nevertheless, we will also touch upon various other everyday life musical activities (which are of many sorts) and contextualize them within our framework.

4.1 Music structural features

Earlier, we discussed the types of emotions that music is often likely to induce. Here, we will briefly discuss how music structure contributes to (and may drive) those experiences.

Music structural features encompass a range of aspects that describe the music signal. At the most basic level, the music (as an acoustic signal) is encoded as an auditory signal. At this level music is mapped onto a new domain which preserves relevant features of its structure for further analysis, but various invariant properties related to microstructural organization are immediately conveyed. The auditory basic perceptual attributes involved in music perception are loudness, pitch, contour, rhythm, tempo, timbre, spatial location and reverberation. While listening to music, our brains continuously organize these dimensions according to different gestalt and psychological schemas. Most of the time, the percept reflects the properties of music's acoustic objects and events very accurately, but the transduction process involves various transformations involving innate as well as culturally determined processes. Some of these schemas involve further neural computations on extracted features which give rise to higher order musical dimensions (e.g., meter, key, melody, harmony), reflecting (contextual) hierarchies, intervals and regularities between the different structural elements. Others involve continuous predictions about what will come next in the music as a means of tracking structure and conveying meaning, both through gestalt and learned expectations (Meyer 1956; Huron 2006). Furthermore, the development of mental schemata reflecting musical and socio-cultural (implicit and explicit) knowledge of some sort (e.g. through music training or exposition to a particular music culture or sub-culture) also plays a critical role in music perception, cognition and emotion.

In sum, music structural features range from microstructural properties of the acoustic signal that very closely describe the features of emanating source and surrounding environment, to a much higher level of structural organization and abstraction, which can convey for instance form and style. By attending to structural aspects of the acoustic signal at these various levels, listeners construe emotional meaning and, although the way that different levels interact is still largely unknown, there is evidence of specific structural cues and patterns communicating similar emotions to all listeners (see Gabrielsson & Lindström 2010 for an in depth review). There is also convincing evidence that music can express emotions that are recognized universally, a phenomenon that is also associated with acoustic profiles which transcend cultural boundaries universally (Fritz et al. 2009; Balkwill et al. 2004; Balkwill & Thompson 1999).

Interestingly, the most consistent relationships between music structure and emotional qualities pertain to the effects of basic variables in human audition, such as loudness and timbre, and motion (e.g., tempo). Concerning higher levels of music perception and cognition structure retrieval, their expressive power seems to be more complex and dependent on the context (i.e., other structural factors). In this context, it is fundamental to mention that there is now converging evidence that points out the existence of acoustic profiles common to the expression of emotion in both speech and music, with particular acoustic codes consistently associated with particular emotion categories (Juslin & Laukka 2003; Ilie & Thompson 2006, 2011) and dimensions (Coutinho & Dibben, in press). These and other studies provide a strong basis on which to purport the existence of a general mechanism for the expression and recognition of emotions in the acoustic domain (Scherer, in press).

In addition to acoustic-related features it is also fundamental to mention, even if briefly, that music can also convey meaning in other sensorial modalities. Indeed, music structure can also convey meaning outside the auditory domain, as is the case of visio-spatial and motion (Colling & Thompson, this volume; Eitan & Granot 2006), as well as tactile (Eitan & Rothschild 2010) metaphors. Such cross-modal interactions in the perception of music can have a strong influence on emotional responses to music, by conveying emotional meaning across multiple modalities which can lead to more intense and multi-faceted emotional experiences. For that, some sort of invariant perceptual qualities must be obtained from the acoustic signal or some aspects of music itself convey some sort of indexical meaning (e.g., sound movement can be an indexical spatiotemporal representation of a gesture; rhythm and tension can also generate indexical sound gestures priming specific targets in the music).

Lastly, it should be mentioned that music-related cues are not the only sensory and perceptual inputs with an impact on the emotional state of the listeners in a given circumstance. Other inputs, and particularly visual ones, which have an impact on the emotional response, are mentioned throughout this chapter in various moments since they become relevant for the description and operationalization of some of the routes (and when concomitant with music). Nonetheless, because our focus is music as the object of emotion, we restricted this section to the identification pertinent levels of interaction between music structure and listener emotions.

4. 2 Listening context

We identify three main groups of features related to the listening context that may affect the listeners' emotional response to the music at various levels: performance features, listener (or individual) features and contextual features. In the context of our framework, all these features may have, directly or indirectly, an influence on the emotions produced by music in a particular listeners or group of listeners. As it will be shown, these features have a modulatory effect not only on the emotional experience itself, but most importantly of the actual routes for emotion production. Thus, in certain circumstances, listening context cues may determine the nature of an emotional experience or even block it. Nevertheless, as we will also see, many of these features may have similar effects across listeners, thus also leading to stereotyped responses.

Performance features

Performance features include two distinct, although intertwined, dimensions, both with a major impact on the perception and induction of emotion. One is intrinsic to the aural experience and corresponds to the way in which a piece of music is executed by a singer and/or one or more instrumentalists. Cues of tempo, dynamics, timing, timbre, and articulation are amongst the most important acoustic building blocks used by performers as a means of achieving emotional expression (e.g., Juslin & Timmers 2010). The second dimension refers to the effects of iconic, indexical and symbolic information communicated during the performance. It includes the stable identity (physical appearance, expression, reputation) and ability (technical and interpretative skills) of the performer as well as transient performance-related variables to which we will call the performance state (interpretation, concentration, motivation, mood) and performance manners (body movements, gestures, stage presence, audience contact, etc.) (e.g., Huang & Krumhansl 2011). All these aspects, isolated or in combination, directly or indirectly, and in the context or a particular listening situation, affect the emotional experiences of a musical performance.

Listener features

The individual and sociocultural identity of the listener and the symbolic coding convention prevalent in a particular culture or subculture are also fundamental modulatory cues in emotional experiences with music. These features can be summarized into musical expertise, including cultural expectations about musical meaning, and stable dispositions (related or unrelated to music). Musical expertise includes those musical capacities acquired through exposure to music with or without the help of explicit training. It should be noticed that the

capacities derived from 'implicit' exposure achieve very high levels of sophistication, in such way that they enable untrained listeners to respond to music as explicitly trained listeners do (Bigand & Poulin-Charronnat 2006). Nevertheless, explicit training can alter the listeners' emotional experiences by priming the understanding of the musical structure in various ways and through an awareness of details in the music that impact their emotions (even at the brain functioning level: e.g., Dellacherie et al. 2011).

Stable dispositions refer to individual differences in age (e.g., motivational and selective neuropsychological decline) and gender, in memory (including learned associations and conditioning; see Jäncke 2008), in inference dispositions based on personality (e.g., Rusting & Larsen 1997), socio-cultural factors (e.g., Basabeet al. 2000), prior experiences (e.g., Bigand & Poulin-Charronnat 2006), physiological reactivity (Penman & Becker 2009), and coherence between emotional experience and physiology (e.g., Sze & Gyurak 2010), among others. In addition, transient listener states such as motivational state, concentration, or mood may also affect emotional inference from music (cf. Cantor & Zillmann 1973). Stable dispositions are also intertwined with exposure to particular music systems (and thus sensitivity performance features and emotional communication). Although listeners across cultures seem to be capable of decoding emotional meaning from unknown musical systems (e.g., Fritz et al. 2009), exposure to a particular system and familiarity with the style or particular piece seem to be a determinant factor in shaping the level of sensitivity (e.g., Daynes 2010).

Contextual features

By contextual features, we refer to certain aspects of the performance and/or listening situation. The location of a performance and/or a listening situation may be a concert hall, church, party, street, car or home. The dominant material surrounding the listener/performer may be wood, glass, stone, metal or none. In addition to the location, the particular event may be a wedding, a funeral, a ball or the celebration of an outstanding achievement. The music may be transmitted through loudspeakers, headphones or without any technical support. The music may be heard without interruption or the sirens of an ambulance or the coughing of a concert visitor may disturb it. 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.

5. Routes

With this initial formalization of the output (emotions), the input variables (structural features), and mediating factors (performance-, listener-, and context-related) involved in emotional responses to music, we can now inquire into particular ways by which emotion may be generated by music. Given the diverse nature of these, Scherer and Zentner (2001) have called these *routes* and provided a number of examples: 1) specific types of appraisal (such as novelty, unexpectedness, pleasantness), 2) music-related memory associations, 3) contagion, and empathy, 4) entrainment and proprioceptive feedback, and 5) facilitation of preexisting emotions (disinhibition). The term *routes* was chosen to emphasize the assumption that only major pathways through the cognitive and emotional systems involved can be traced, with each of these recruiting a large number of neural and somatic structures and many different mechanisms in terms of the underlying machinery.

More recently, Juslin and Västfjäll (2008) have suggested a list of "mechanisms" which is quite reminiscent of the list of routes proposed by Scherer and Zentner (2001), except for the notable lack of the appraisal route. These authors consider a revised version of this proposal as a unified theoretical framework called BRECVEM (see also Juslin et al., 2010) which stands for Brainstem reflex, Rhythmic entrainment, Evaluative conditioning, Contagion, Visual imagery, Episodic memory, and Musical expectancy. Three of these mechanisms can be subsumed under the appraisal route described by Scherer and Zentner: brainstem reflex as low level novelty and intrinsic pleasantness check, evaluative conditioning is the precondition for creating valenced associations for many types of appraisal, and musical expectancy corresponds to what is described as part of the Discrepancy of Expectation check. Episodic memory is covered under the memory mechanism, as is visual imagery in the form of memory dependent constructive imagination. Empathy and emotional contagion cover Juslin and colleagues' contagion mechanism, but go much beyond this single mechanism. Rhythmic entrainment was covered under proprioceptive feedback, which also contains mechanisms lacking in BRECVEM (which also does not cover the facilitation emotion route).

While the review of the literature provided in the Juslin and Västfjäll (2008) paper is useful, the status of the proposal as a "unified theoretical framework" is dubious. It is doubtful whether the seven mechanisms listed are an exhaustive set of possible or even likely

mechanisms (e.g. brain stem reflexes). The 'mechanism status' of several entries in the list is unclear if one applies Marr's (1982) distinction between three levels of function, the computational, the algorithmic, and the implementational levels. For example, contagion seems to operate on the computational level, evaluative conditioning on the algorithmic level, and brainstem reflexes on the implementational level. Thus, the proposed mechanisms seem to be situated on different levels of function. Furthermore, as in many cases multiple mechanisms are likely to operate, a unified framework would require a discussion of potential interaction. The complete absence of multilevel appraisal as a central mechanism underlying several of the phenomena discussed, in particular musical expectancies, is also difficult to understand. And it seems unfortunate that the appraisal of goal conduciveness in the framework of music listening motivation (covered by several chapters in Juslin & Sloboda 2010) is completely neglected. These problems notwithstanding, the renewed emphasis on the mechanisms underlying the emotional power of music is to be greatly encouraged as it is essential to conduct more theory-guided research, using appropriate experimental paradigms, to elucidate at least some of the many open questions.

-- Figure 3 about here --

Here, we extend and reformulate the suggestions made by Scherer and Zentner (2001) in an attempt to systematize the proposal and illustrate the suggestions with concrete examples. The following sections describe the major routes or pathways underlying the production of emotions in the listeners. In order to tie these routes to the emotion architecture proposed by the CPM, we will use Figure 3, an extension of Figure 1, to illustrate the major routes, as identified by the bold arrows in the figure labeled from A to E. In addition we will illustrate the concrete mechanisms that might be recruited for specific routes. Concretely, we postulate five major routes:

A Appraisal
B Memory
C Entrainment
D Emotional contagion
E Empathy

5.1 Appraisal (route A)

Given that the term ‘appraisal’ is now used, in some form or function or another, by almost all emotion theorists (Moors & Scherer, in press), there seems to be convergence about the central role of appraisal in the emotion process. It is thus to be expected the mechanisms described by emotion psychologists may also be applicable to the study of emotion induction via music. Indeed, appraisal seems to have a pervasive role in emotional induction through music. On one hand because music structure percepts and representations must be evaluated at some point for their emotional meaning and/or relevance to the individual. On the other hand, because appraisal is central to the emotion induction process by continuously driving and coordinating activity on the various emotion subcomponents.

As outlined in the description of the CPM, the appraisal process may occur in a rudimentary, automatic fashion at lower levels of the central nervous system (mostly the limbic system, including the brainstem), especially for evolutionarily ‘prepared’ stimuli, or in a series of more elaborated and more effortful processes involving the higher regions of the central nervous system. Indeed, music structural features can trigger low-level emotional appraisals by means of innate detection mechanisms of relevant affective information. For instance, considering the link between vocal and musical expression of emotion discussed earlier, it is plausible to assume that musical stimuli that share the acoustic characteristics of such fear vocalizations (sudden onset, high pitch, wide range, strong energy in the high frequency range) may be appraised by the evolutionarily low-level but extremely powerful detection systems and may provoke physiological defense responses in a similar way to pictures of spiders or facial expressions of fear (see Vuilleumier 2005). It should be also noted that similar automatic evaluation processes can occur for auditory stimuli that are not themselves evolutionarily prepared but that have been conditioned to such stimuli by occurring repeatedly at the same time (LeDoux 1996).

Similar low-level detection mechanisms can be demonstrated for the appraisal criteria of suddenness/novelty and intrinsic pleasantness (see Scherer 2009). There is some evidence that musical sounds can generate strong suddenness/novelty (particularly for evolutionary prepared stimuli, see below) and, in particular, intrinsic evaluations of pleasantness. A good example is perceived roughness, and particularly sensory dissonance. For instance, studies of infants’ perception of music show a preferential bias favoring consonance over dissonance as early as 4-months-old, suggesting that the human infant might possess a biological

preparedness that makes consonance more attractive than dissonance (Zentner & Kagan 1996, 1998).

Appraisals of music structure can occur at the various structural levels outlined in Section 4.1, although the object and context of such evaluations is not always clear. An interesting possibility that, so far, has not been much explored in the psychology of emotion, is that, either as a part of intrinsic detection of importance or as a separate mechanism, there may be automatic evaluation of aesthetic qualities. Thus, it could be that there are some universal criteria of beauty that are evaluated automatically on the basis of visual and auditory stimulation and give rise to an affective response. Such a prepared aesthetic response has been postulated for landscape preferences, a claim which has found some empirical support (Kaplan & Kaplan 1989)

Turning now to the operationalization of appraisal, including higher level appraisals, we will provide some examples of how the different appraisal checks briefly outlined in the section describing the CPM model can apply to emotion generation in listening to music, grouped by the major aims of appraisal. It should be noticed nevertheless that, due to the generality of appraisal checks, they apply to musical and non-musical objects. Hence, the various checks have different levels of predominance in musical and non-musical contexts which is also related with the fact that different types of goals may be involved (sometimes even dependent on the music activity itself). Future work should explore the extent to which the various appraisals checks may be weighed differently for music during the integration of top-down processes providing contextual information that alter the contribution of a particular check of an appraisal. In addition, new checks, uncommon to non-musical stimuli, such as domain-specific musical expectations, may play an important role in music appraisal.

The first group of checks evaluates the *relevance* of the sensory input. A stimulus event is considered as requiring attention deployment, further information processing, and potential action. Three subchecks are involved:

> *Novelty*. Here we can distinguish three subchecks: suddenness, familiarity, and predictability. All three of these are highly pertinent to music. As mentioned above very abrupt onset of sound, sharp attack of the amplitude and pitch envelopes, and sudden tone shifts (processed at the automatic level) can produce strong emotional

effects through low-level appraisal. As mentioned earlier, familiarity has a strong impact in the listener emotional experiences. To appraise familiarity we need to proceed to pattern matching with stored schemata and/ or association based processing, a process strongly modulated by listener's musical background. This is turn is linked to predictability: there is evidence for increasing anticipation of emotional events with familiarity (Daynes 2010), and musical sounds conforming to the Western system of harmony are more predictable to Western listeners than Asian music systems (Balkwill et al. 2004) or some experimental contemporary music (Daynes 2010).

Intrinsic Pleasantness. As mentioned above this is a central aspect of musical emotions and it is often processed at the automatic level (e.g., consonance and dissonance). But there can also be other levels of processing involved—for example, the conscious determination whether a particular musical structure corresponds to a classic ideal of beauty, or the result of repetitive exposure to particular music pieces, genres and cultures.

Goal relevance. Does the event have consequences for my needs or goals? For aesthetic emotions, where the main goal of the activity is, at least in part, the experience of certain positive emotions or at least bittersweet emotions, an important consequence might be whether I will really enjoy the music and experience one of the coveted emotions. Or else, it could be a quest for new experience, having insight, acquiring knowledge (the epistemic emotions). Nevertheless, the pervasiveness of music in everyday life and its concomitance with various physical and cognitive tasks points out other levels of relevance in engaging in musical activities. Furthermore, music is known to support and powerfully modulate cognition as well as to regulate arousal and emotion and thus, pleasure and emotional regulation can also be goal states (e.g., to pass the time, keep awake, achieve desired level of arousal).

The second group of checks concerns *implications*. Following attention deployment, the pertinent characteristics of the stimulus event and its implications or consequences for the organism are determined. There are three sub-checks that evaluate this criterion:

Outcome probability. How likely is it that the desired consequences will occur? For a familiar piece of music, this may depend on the performer, for an unknown piece this might be an important criterion for some emotions to occur (e.g., boredom). For the purpose of emotional regulation, a pervasive use of music, it may depend on the achievement of a target emotional state.

Discrepancy from expectation. How different is the situation from what I expected it to be? This check is extremely important for music processing as it ties in directly into the central issue of musical expectancies, which has been one of the earliest music-related appraisals highlighted by the pioneering work of Leonard Meyer (1956) on the emotional meaning. Importantly, the appraisal of the discrepancy of temporal or melodic expectancies can occur on a micro-level, within phrases, or in much larger time frames. The operation of the expectancy check has been copiously studied and there is now a large amount of literature on the topic (Huron 2006; Lerdahl & Krumhansl 2007; Patel 2008, to name but a few). The inputs to this check are not only low-level proximal cues, but also the results of various hierarchical neural computations applied to those. These provide crucial information about the stimulus at different levels of music perception and cognition making use of innate and acquired mappings and models. These processes are strongly mediated by individual factors, such as, familiarity, exposure, and expertise (e.g., Daynes 2010).

Conduciveness. Is the event conducive or obstructive to reaching my goals? This is of course determined by the goals underlying the choice of listening to music or by the present goals of an individual when hearing music was not a choice. In both cases this sub-check is central for the outcome—in music as for all other types of stimulation or events.

Urgency. How urgently do I need to react? This appraisal is important for utilitarian emotions but unlikely to play a major role in music listening, especially as the time frame for the listening experience is generally well circumscribed.

The third group of checks concerns coping potential. Once nature of event and consequences are known sufficiently well, the organism checks its ability to cope with the consequences to be expected.

Agent and intention. Who was responsible for a particular consequence to be expected and what was the reason? The most important factor in the case of music listening is probably the decision whether it is the composer, the performer, or oneself as a listener who is responsible for example for expectancy violations or goal obstructive consequences. An important qualification is the estimation of whether this is due to competence, effort, or intentionality.

Control. Can the event or its consequences be controlled by human agents? *Power*—do I have sufficient power to exert control if possible? *Adjustment*—if control is impossible, how well can I adjust to the consequences? All of these checks are unlikely to play a major role in passive music listening as the control and power relationships are pretty much mapped out for the ritual occasions of music listening. However, one interesting factor for the resulting emotion might be if I can stop the music or easily leave its range of audibility. In the case of actively practicing music in a social context, this may well be a rather important factor. It should be stressed that music can lead to undesirable effects much stronger than mere displeasure. Some physical effects (e.g., raised blood pressure and stress hormones) may be hard to deal with for some listeners, and, although rare, unwanted loud music can even trigger fits among epileptics. Control is certainly a fundamental sub-check in these situations.

The fourth and final group of checks concerns *normative significance*, the overall assessment of the event with respect to its compatibility with one's self-concept, and values on the one hand and the dominant social-norms, and moral rules on the other.

The evaluation of the *compatibility of a stimulus event with external standards (norms, cultural values) and internal standards (personal values)* as part of the appraisal process is highly relevant for the elicitation of emotion via music. There seem to be prescriptions specific to culture and/or historical periods as to what is aesthetically pleasing, beautiful, and even what is to be rejected as a violation of 'good taste' (Farnsworth 1969; Kenyon 1991; see also Lynxwiler & Gay 2000, for an interesting recent example). Throughout musical history, the social norm or standards criterion has been involved in powerful emotional reactions towards 'modern' music, which was seen as violating established standards of morality and decency. The well-known

scandal provoked by the première of Igor Stravinsky's dissonant and polyrhythmic *Sacre du Printemps* or by the première of Edgar Varèse's surreal *Deserts*, both in Paris, are just two particularly drastic examples of strong emotional reactions to the perceived disregard of established standards. In relation to one's values and musical identity, it is important to mention the use of music as a means and source for developing individual identities, to conform to a particular group, or to society in general. Obviously, the role of other society members has a fundamental role in this process, but also the way that we define ourselves on relation to music (e.g., Hargreaves et al. 2002).

5.2 Memory associations (route B)

Memory is fundamental for music. Auditory signals unfold over time, thus it is necessary to keep track of ongoing information to coherently construct multi-dimensional perceptual objects from sequentially ordered sounds. This is a process in which the working memory plays a major role as in speech processing. In terms of their involvement in routes of emotion elicitation, there are two particularly important memory mechanisms to be mentioned: episodic and associative. Episodic memory permits that specific (strong) emotional reactions that an individual has experienced in the past resurge in memory, spontaneously or triggered by a specific cue, or are evoked due to an instruction to vividly imagine the event (Blaney 1986; Christianson 1992). Expressive and physiological reaction patterns to emotion-inducing events are likely to be stored in memory together with the experiential content (Lang 1979; Lang et al. 1980). Music, like smell, seems to be a very powerful cue to bring emotional experiences from episodic memory back into awareness. This is not surprising, for two reasons. Firstly, music is quite a pervasive element of social life and accompanies many highly significant events in an individual's life, such as religious ceremonies, marriage, burial rites, dancing and other festivities, etc. Thus, there are many associations between musical elements and emotionally charged memories. Second, music, again like smell, may be treated at lower levels of the brain that are particularly resistant to modifications by later input (e.g. LeDoux 1992). There may be other aspects of the memory system involved in this route, e.g., perceptual and semantic memory, which we cannot cover here because of lack of space.

By means of associative memory, in addition to straight recall of events or objects from the past, it is possible to associate and combine elements of memory to construct scenarios or visual images and auditory impressions via imagination. It is often claimed that recall of past

emotional experiences from memory and imagination can evoke similar emotional reactions as in the original experience. The empirical evidence for such memory-induced resurgence of expressive and physiological reactions is still scarce (see review by Jäncke 2008).

5.3 Entrainment (route C)

Music is likely to produce emotion states through a route that is independent of appraisal or memory—via direct influence on the peripheral nervous system and spread to other emotion components. One potential candidate for such influence is *entrainment via rhythm*. We all know the contagious effects of strong musical rhythms, at least on susceptible individuals who find it difficult not to move their heads or their legs in unison with the rhythm (e.g. in the case of dance rhythms, marches, or techno beat; see also Zentner & Eerola 2010). Recent evidence suggests that such coupling of internal rhythms to external movements, as originally described by Byers (1976), might be present already at a very early age (Rochat & Striano 1999). If there is indeed a fundamental tendency for synchronization of internal biophysiological oscillators to external auditory rhythms (entrainment), such coupling may provide a promising explanatory venue for the emotion-inducing effects of music (see Bispham 2006; Fitch, in press).

As discussed earlier, an internal or external object or event can lead to the activation of various response systems including the autonomic and somatic nervous systems. But the opposite can also happen, that is, the state of the response systems can also become the triggering event of an emotional episode. Currently, neurobiological models of emotion recognize not only the importance of higher neural systems on visceral activity (top-down influences) but also influences in the opposite direction (bottom-up) (see Berntson et al. 2003 for an overview). While the top-down influences allow cognitive and emotional states to match the appropriate somato-visceral substrate, the bottom-up ones serve to bias emotion and cognition towards a desired state (e.g., guiding behavioral choice, Bechara et al. 2003).

An important aspect of physiological activation is its interaction with other emotion components. Indeed, physiological activation can also affect the subjective feeling of an emotion, a process known as peripheral feedback. Its role as a mechanism to generate emotion from music is based on the idea that the emotion system consists of integrated components and that the system as a whole can be activated by manipulating the patterning of one of its components, that is, it can have multiple initiation points (see Ekman et al. 1983). The general

idea is also consistent with proprioceptive feedback theories (e.g. facial feedback, McIntosh 1996) which claim, in their strong form, that subjective feeling can be produced, or in their weak form, enhanced or intensified, by increased or uninhibited motor expression (see also Laird 2007). In the context of music, Dibben (2004) investigated the role of physiological arousal in determining the intensity and hedonic value of the emotion experienced while listening to music. Results show that the group of participants with induced physiological arousal reported more intense emotions 'felt' than those without, providing strong evidence that physiological arousal influences the intensity of emotion experienced with music. Furthermore, Coutinho and Cangelosi (2011) have suggested that by considering peripheral physiological activity the accuracy in addition to proximal cues for the prediction of subjective feelings of emotion in response to music the accuracy could be improved.

5.4 Emotional contagion (route D)

In the case of the routes involving the mechanisms and processes described above (appraisal and memory mediated routes), we focused mainly on emotion elicitation based on the processing of intrinsic proximal cues, i.e., those inherently psychoacoustic. However, as mentioned, emotional reactions can be elicited by direct effects of extrinsic cues which can be derived from the aural stimulus itself (e.g., audio-tactile metaphors, images of motion, tact) as well as from externally observed emotion expressive cues in others (e.g., body movements, facial expressions). One somewhat speculative, but interesting, possibility is that mirror neuron system mechanisms might be involved (Overy & Molar-Szakacs 2009).

As an example, we can be infected by the joy of others at a successful party, being the essential feature here the observation of the motor expressions of the persons concerned. The assumption is that the sheer observation of strong motor expressions can produce similar muscular reactions in ourselves, a process generally called "motor mimicry", that has been at the center of a theory of emotional inference suggested by the German philosopher and psychologist Lipps (1909). He argued that understanding the emotions of others occurs through Einfühlung (a term for which "empathy" is not quite the correct translation) is based on our mimicking, at least in a rudimentary fashion, the expressive patterns we see in the other (i.e. a contagion, at least of the expressive movement). This process may occur in quite an unconscious fashion, simply by observing and possibly internally mimicking the expressive movements. In this case, one would experience similar emotions as the observed models (or at least change our experiences towards those models). In the case of a musician

performing a musical piece, there is evidence that the expressive movements and practice methods of the performer(s) lead to emotional contagion, and may even influence the perception of music structure (e.g., Vines et al. 2011).

Davies' (in press) proposes that:

> … music is expressive because we experience it as presenting the kind of carriage, gait, or demeanor that can be symptomatic of states such as happiness, sadness, anger, sassy sexuality, and so on. If contagion operates through mimicry, we might expect the listener to adopt bodily postures and attitudes (or posturally relevant muscular proprioceptions) like those apparent in the music's progress. Vocal mimicry, in the form of subtle tensing or flexing of vocal muscles, would also be a predictable response to vocal music or to acts of subvocal singing along with instrumental music. And where the flux of music is felt as an articulated pattern of tensing and relaxing, this is likely to be imaged and mimed within the body, perhaps in ways that are neither subpostural nor subvocal.

Juslin and Laukka (2003), having established a large degree of overlap in the acoustic cues indexing emotions in speech and music, suggest that musical instruments may serve as "super expressive voices" and that this may produce empathy or contagion with an imaginary speaker. However, it remains to be established whether a detour via voice imagery is necessary for contagion or whether the iconic character of the specific acoustic patterns for certain types of emotions is not sufficient. In general, even for facial mimicry, which has been very frequently studied in recent years, the precise mechanisms have not yet been established with precision, and much further work on the vocal/acoustic domain remains to be done in this respect.

5.5 Empathy (route E)

Emotions can also be elicited by observing another person being affected by an event that is very important to him/her but not necessarily to us. Through *empathy* we have feelings of concern for other people, we experience the emotions that others feel, and we "know" what others are thinking and what it would be expected to feel in a particular situation. Such a socio-emotional competence is crucial in human interactions (e.g., mother-child bonding) because it smudges the line between self and other (Decety & Svetlova 2012). Thus, the

process of empathy is different from simple contagion (which can work through expression only) in that the observer has to put him/herself into the shoes of the observed and simulating the latter's motivation and appraisal processes, which helps us to understand the other's emotion and feel compassion.

In the case of music, empathy is particularly important in live performances and in social listening settings (e.g., parties) and, as in the case of emotional contagion, non-musical cues play an essential role. For instance, emotional responses may be mediated by empathy through an understanding of the performers (or other listeners) emotional states, as well as their possible relation to imaginary events or underlying "ideas". Naturally this process is concomitant with the perception of emotional expressions and music structure, and thus the emotional contagion and appraisal routes, with which may interact in multiple ways. Interestingly, music induced emotions (including physiological arousal) are also generally affected by manipulations of empathy towards the performers (Miu & Baltes 2012) and by individual differences on empathy scores (Wolner 2012). It is also worth noticing that empathy may facilitate the induction of negative emotions (Vuoskoski & Thompson 2012).

6. Conclusion and outlook

In this chapter we have attempted to review possible answers to the question of how music creates emotions in listeners. We have emphasized that a precondition to answer this question is to agree on the nature of the reaction of a listener to piece of music that one wants to qualify as *emotional*. We have acknowledged that music can evoke many different affective states, including preferences and moods. However, we focused on more constrained definition of properly emotional reactions to music as based on convergent definitions in the current literature and using the first author's Component Process Model of emotion (CPM) as a guide. Importantly, we have suggested differentiating between three fuzzy sets (as there may be multiple blending) of emotions—utilitarian, aesthetic, and epistemic. These classes differ in the nature and importance of the eliciting objects and events, the central appraisal criteria involved, and the nature of the response patterns in the different components. We submit that this distinction is useful to promote empirical research on emotion induction by music as it not only provides a theoretical framework, generating concrete hypotheses to be tested, but also informs the development of research tools such as scales for the assessment of self-reported emotional reactions (as we have shown using the example of the development of the Geneva Emotional Music Scale (GEMS) and its offshoots).

The bulk of the chapter presented an extension and further development of a theoretical framework proposed by Scherer and Zentner in 2001. Starting from the notion that research on emotion induction by music should focus on music characteristics, more precisely the musical structure and performance variables, we also accounted for the modulation of these central effects through factors related to listener characteristics and states as well as a host of context features. We mostly illustrated the type of factors by providing examples, as restricted space did not allow us to review the pertinent work in this area in a comprehensive fashion. We feel that such a review would be timely, especially if it were to adopt a systematic theoretical organization that could help to encourage research designs that do not focus on single factors but attempt to examine multifactorial interactions.

In particular we aimed at extending and enriching the discussion on the precise mechanisms that are involved in the process of the elicitation of emotion through music. We tried to demonstrate that the various mechanisms underlying the production of emotion through music are various and ubiquitous. Furthermore, we have tried to show that these mechanisms can be recruited (in various combinations) at various levels of the emotion induction process. Hence, the process of emotion induction through music is better operationalized as routes, that is, psychobiological pathways recruiting various subsystems of the central and autonomous nervous systems. In this way, it is possible to describe the nature and substrate of eclectic emotional responses to music, and to the variety of possible modulatory effects that pertain to particular or all mechanisms.

Routes also relate to the nature and function (implicit or explicit) of the various musical activities. For instance, music can be used as a source of emotional experiences or a means for emotional regulation, and in this case most routes described are likely to be implied in one way or another. But emotional experiences with music also exist (and are at the base of some of its uses) in the context of cognitive enhancement or physical recovery, and not only when listening to music is at the very center of the listener's goals. In these cases, it is more likely that other ongoing processes, appraisals and the background emotion state have an impact on the listeners.

We also emphasize that, in this chapter, we have only discussed the production of emotions where there were none before, although the enhancement of existing emotions has been

touched upon. However, emotions induced by music are not absolute phenomena, and they largely depend on the listener's ongoing processes and appraisals. Thus, emotional responses to music can be blocked or potentiated by extraneous factors to the music or situation, but nevertheless of relevance to the listener. This seems to be a natural consequence of emotions mechanisms being shared by musical and non-musical stimuli. Another potential effect of listening to emotionally arousing music can be the weakening or the elimination of control or regulation over emotional expression. Due to socio-cultural display and feeling rules, or because of strategic considerations, emotional reactions are often highly controlled or regulated, both with respect to motor expression and subjective feeling.

It is to be hoped that the recent theoretical activity, including critical debate, concerning the issue of emotion induction by music and the underlying mechanisms will help to generate empirical research to test and validate some of the major assumptions proposed here and in other work on the topic. Given the theoretical framework that we have proposed here, one of the major preconditions for successful research ventures in this area would seem to consist in the development of methods that allow to determine, using objective criteria, whether or not an emotion process, as defined by the synchronization of response patterns in different components, is indeed occurring. While verbal self report of emotional experiences, the most frequently used dependent variable in this research, remains a major access to processes internal to the listener, it should be complemented, whenever possible, by other indicators of appropriate response patterns such as motor expressions (facial, postural) or neurophysiological responses. In addition to allowing a more comprehensive assessment of listener reactions, the latter behavioral indicators have the advantage of allowing continuous measurement—and thus the possibility of closely aligning them with the dynamic changes in musical structure.

As mentioned at the outset, the emotional effects of music have fascinated scholars for the last two millennia. As we have seen, there are no simple answers given the huge number of factors involved and their intricate interactions. But the explosive development of research activities in this area, the progress being made in both theory and methodology, and in particular, the nascent tendency of composers, performers, and an informed part of the public to interact with researchers, promise to further our understanding of the emotional power of music in the near future.

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