

Music-evoked emotions: principles, brain correlates, and implications for therapy

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This paper describes principles underlying the evocation of emotion with music: evaluation, resonance, memory, expectancy/tension, imagination, understanding, and social functions. Each of these principles includes several subprinciples, and the framework on music-evoked emotions emerging from these principles and subprinciples is supposed to provide a starting point for a systematic, coherent, and comprehensive theory on music-evoked emotions that considers both reception and production of music, as well as the relevance of emotion-evoking principles for music therapy.

Keywords: brain; music; emotion

Introduction

This paper describes and discusses principles underlying the evocation, modulation, and termination of emotions and moods. The thinking on this issue is in line with two milestone articles on this topic, one by Scherer and Zentner,¹ the other by Juslin and Västfjäll.² Here, I enumerate seven principles and also provide brief examples for their relevance with regard to music therapy (MT). This conception partly overlaps with, and partly differs from, the “mechanisms evoking emotions” suggested by Juslin and Västfjäll,^{2,3} or the “rules” underlying the “production of emotions” with music by Scherer and Zentner.¹ The most salient differences are that (1) the present framework is supposed to hold for both reception and production of music, (2) the framework considers the relevance of emotion-evoking principles for MT, and (3) it considers two principles that have not been considered by other frameworks (understanding and social functions).

Instead of using the terms *mechanism* or *rules*, the term *principle* is used in the following because the notion of mechanisms that induce emotions with music,³ or of rules that produce emotions,¹ pertains to only a subset of emotional phenomena and sounds as if musical antecedents always determine

a specific emotional effect. This, however, does not seem to be the case; otherwise, depressive patients could easily be healed with happy music. Similarly, the term *music-evoked emotion* is used instead of *music-induced emotion* or *music-produced emotion* to emphasize that some emotional effects cannot be caused (or intended) in a deterministic way. Note that a common view in MT is that emotional effects with therapeutic consequences have to be understood in the context of the personal situation of the patient; this view stays in contrast to common Western medical practice, where, for example, a chemical compound is administered to induce and correct something that is supposedly wrong, or deficient, with the patient.

Evaluation

Evaluative processes are the most researched and most theoretically described emotion-evoking principle (also referred to as appraisal). The theories that deal with emotions as the result of evaluative processes are referred to as *appraisal theories*. A common tenor of these theories is that (external or internal) phenomena, circumstances, actions, individuals, or objects are evaluated as “good,” that is, contributing to achieving a goal, or “bad,” that is, obstructing

the achievement of a goal. In particular, music often has specific functions for individuals (listeners, dancers, composers, players),⁴ such as regulating emotions, diversion (e.g., to prevent boredom or to direct attention away from unwanted thoughts), and social functions. Thus, music is often used to obtain a specific goal, and attaining such a goal evokes positive emotions. For example, in a study using the experience-sampling method, more than 65% of the episodes in which music evoked an emotion, individuals used music to “get some company,” “to relax,” “to get energized,” “to pass the time,” or “to influence feelings.”⁵ Note that Juslin differentiates such goals from “a goal being involved in the underlying process through which the music produces its emotional effect”³ but concedes that, although such phenomena are rather seldom the cause of an emotion, these phenomena nevertheless exist.^{3,5}

Scherer⁶ noted that evaluative processes can occur on a sensory–motor, a schematic, and a conceptual level (p. 103). The sensory–motor level represents reflex systems responding to stimuli that are innately preferred or avoided. The schematic level includes learned preferences/aversions, and the conceptual level includes recalled, anticipated, or derived positive–negative estimates. Thus, evaluative processes can take place on different levels of the brain (and, thus, on different levels of perceptual and cognitive processes). These levels include the brain stem (e.g., perceptual processes, loudness, dissonance), the diencephalon (e.g., when homeostatic needs arise or are fulfilled), the orbitofrontal cortex (OFC; e.g., when social norms are fulfilled or violated), and the neocortex (e.g., in the course of conscious and deliberate reasoning). Note that evaluative processes can be (1) automatic and noncognitive (e.g., evaluative processes occurring at the level of the brain stem or the diencephalon), (2) automatic and cognitive but without awareness (processes at the level of the OFC),⁷ or (3) cognitive with involvement of conscious awareness (processes at the level of the neocortex). On each of these levels several evaluative processes can be carried out. In his sequential check theory of emotion differentiation,⁶ Scherer proposed several sequential checks underlying the evaluation (appraisal) of stimuli. These checks include relevance detection (including a novelty check), implication assessment, coping potential determination, and normative significance evaluation. Note that some of these

checks can only be performed by cortical structures, such as normative significance evaluation.

Scherer and Zentner have outlined a number of appraisal processes with regard to music (referred to as *production rules* by the authors).¹ These appraisal processes are determined by the musical structure, the quality of the performance, the expertise and current mood or motivational state of the listener, as well as by contextual features such as location and the form of the event.

Here, I suggest that evaluative processes are due to (1) perceptual features (such as loudness, timbre, and dissonance), (2) contextual features (situation, form of the event, location, familiarity with the piece, expertise, and mood of the listener), (3) interpretation and symbolic features (although the music might sound pleasurable, music might evoke a negative emotion because it represents something that is imbued with negative emotional valence; see, e.g., the avoidance of Wagner’s music by Jewish survivors of the Nazi terror), (4) composition and musical structure, (5) quality of the performance, (6) affective functions (feeling, regulating, and savoring emotions and moods), and (7) social functions (discussed further below). Note that these different evaluative processes, or dimensions, are, at least to a certain degree, orthogonal or independent of each other. For example, a piece might be appreciated because of its beautiful sound, although its structure does not give rise to a positive evaluation. Or the artistic quality of a “happy-birthday-to-you” singing might be low, but the singing is evaluated as positive because it fulfills a social function.

One important means in many MT approaches is to use music to regulate emotions and moods of patients. This includes the use of music to reduce pain, worries, and anxiety (in both MT settings and clinical settings without a music therapist).

Resonance

Emotional resonance, also referred to as *emotional contagion* or *mimesis*, refers to the evocation of an emotion due to any kind of mirroring, “copying,” or mimetic process. There is surprising scarcity of research on this emotion principle, and to my knowledge only two studies have addressed this issue with regard to music^{8,9} (although a number of studies investigated effects of facial expression of service personnel on customer emotions).

In the face of a lack of empirical research, I theoretically derive and discuss different dimensions of such mimetic processes in the following. (1) At the level of the brain stem, sounds can modulate arousal (calm/excited) via the auditory–limbic pathway, and sounds can induce movements via the saccular–auditory pathway.^{10,11} Moreover, humans have mechanoreceptors that are sensitive to vibrations (the Pacinian corpuscles) and thus resonate with sounds, particularly with low-frequency sounds. The Pacinian corpuscles are located not only in the skin but also in tendons, bones, several organs in the abdomen, and the sexual organs, and it is plausible to assume that their stimulation by musical sounds gives rise to affective responses. (2) The term *emotional contagion* usually refers to the process by which an individual perceives an emotional expression (facial, vocal, gestural, and/or postural) and then copies this expression internally via mirroring processing in terms of motor expression and physiological arousal (for a discussion with regard to music, see Ref. 3). For instance, music might express joy (due to, for example, faster tempo and large pitch variation), this expression is copied by the listener in terms of (covert or overt) smiling, vocalization, and/or bouncing, and the (peripheral) feedback of these motor acts evokes an emotion (see also Ref. 12). (3) However, it is likely that many emotions (in particular, mixed emotions and emotions other than the “basic” emotions) are not simply “copied” by mirroring processes, and even “basic” emotions can presumably be “copied” even without mimicking processes.¹³ Beyond, and in addition to, contagious processes due to mimicking and feedback, music can also lead to empathy (involving self-awareness and self/other distinction) by virtue of relating an emotional expression of music to a previous musical context and/or by adding knowledge about emotions and one’s own emotional experiences. For example, while the spreading of crying in a group of babies is due to emotional contagion, empathy (i.e., experiencing an emotional state that is isomorphic with the state of another individual) as well as sympathy (e.g., feeling pity with another individual without feeling the emotion of the other individual) involves “knowing how the other individual feels” and “knowing how I would feel in a similar situation;” thus, both empathy and sympathy require self–other distinction, contextual knowl-

edge, and knowledge about one’s own emotional experiences. Note that the facial expression of an observer mimicking the emotional expression of another individual might not necessarily be due to emotional contagion but could also be the result of empathic processes and fulfill the purpose of communicating that the emotion expressed by an individual was (correctly) understood by the observer. (4) Music can evoke the cognitive representation of the syntactic structure of the piece (for representations on a short timescale, see, e.g., Ref. 14). Thus, the perceived structure is also (cognitively) mirrored in the listener, and it is plausible to presume that such representations have effects on affective processes. Many people report that perceiving the structural clarity of a music piece sparks their thoughts and reduces negative emotions related to, for example, worries and depressed feelings. However, empirical research on this topic is still lacking. (5) Via cortical mirror functions, movements related to playing an instrument, dancing, or singing are mirrored. Such mirroring might motivate one to move, and the nature of the perceived movements might also incite emotional processes; these issues, however, remain to be investigated.

In MT settings, emotional mimesis as evoked by music (as well as by words, facial expressions, and gestures) is used to create an emotional atmosphere that is most beneficial for the patient. This atmosphere can, for example, be calming, relaxing, playful, sincere, or intimate.

Memory

Emotions and stimuli associated with emotions can be memorized. With regard to music, a musical stimulus might evoke (1) a conditioned response,³ or it might evoke an emotion because it is (2) associated with an autobiographical memory of an event (referred to by Juslin as an episodic memory mechanism).³ With regard to autobiographical events, the perception of music associated with that event can evoke the emotional memory representation of that event³ (for an fMRI study on music-evoked autobiographical memories and emotional effects, see Ref. 15). (3) Musical information with symbolic sign quality (due to semantic memory) might evoke a concept with emotional valence, which in turn might also lead to an emotional response (see Ref. 16 for possible neural correlates of a semantic and an episodic

musical memory, and Ref. 17 for a comparison between a semantic musical memory and a semantic language memory).

With regard to MT, it is important to note that some patients with Alzheimer's disease (AD) have nearly preserved memory of musical information (they remember familiar popular tunes).^{18–20} Although so far not empirically tested, music therapists report that the experience of having a “preserved memory island” on which a patient can still remember music (and music making) and even learn new music has strongly positive effects on the mood of AD patients.

Musical expectancy and tension

Musical sounds are not random and chaotic but are structured in time, space, and intensity. Perceiving musical structures has emotional effects that only emerge from the music itself, and the different emotions arising from processing intramusical structure are summarized under the concept of musical tension.

The structural factors that give rise to musical tension have been reviewed elsewhere¹¹ and are thus only briefly enumerated here. (1) Acoustical features such as sensory consonance/dissonance, loudness, and timbre can increase or decrease tension due to an increase or decrease in (un)pleasantness. In addition, the perception of acoustic information leads to low-level acoustical predictions²¹ and is itself modulated by higher level predictions and inferences.²² The combination of acoustical elements leads to the buildup of musical structure, and the interest in this structure (e.g., its continuation, its underlying regularities, or its logic) is one aspect of musical tension. (2) The stability of a musical structure also contributes to tension, such as a stable beat or its perturbation.²³ In tonal music the stability of a tonal structure is related to the representation of a tonal center.²⁴ Moving away from a tonal center creates tension, and returning to it evokes relaxation.^{25–27} Moreover, the entropy of the frequencies of occurrences of tones and chords determines the stability of a tonal structure and thus the ease, or difficulty, of establishing a representation of a tonal center.¹¹ (3) In addition to the stability of musical structure, the extent of a structural context contributes to tension.²⁸ For example, after a dominant seventh chord, the next chord is

most likely to be a tonic. Thus, the uncertainty of predictions for the next chord (i.e., the entropy) is relatively low during a dominant seventh chord (and relatively high, e.g., during a submediant, because many different chord functions are likely to follow). Progressing tones and harmonies thus create a flux of constantly changing (un)certainly of predictions for the next chord (i.e., an entropic flux). The increasing complexity of regularities (and thus the increase of entropic flux) requires an increasing amount of (usually implicit) knowledge about musical regularities to make precise predictions about upcoming events.²⁹ Tension can emerge from the suspense about whether a prediction proves true (and correct predictions in more complex systems are probably perceived as more rewarding). Therefore, different musical systems and styles can produce different degrees of tension, depending on the sociocultural purpose of music. (4) Tension can be further modulated by a structural breach, that is, by an event that is unpredicted given the model of regularities mentioned earlier (such as a deceptive cadence in tonal music). The unpredicted event has high information content³⁰ (and might be perceived as rewarding because such events help to improve the model).³¹ The emotional effects of the violation of predictions include surprise.³² In contrast to everyday surprise, in tonal music these surprising events also evoke tension emerging from the delay of the resolution of the sequence. Interestingly, violations of predictions occur even despite veridical knowledge of a piece because of the automatic (nonintentional) application of implicit knowledge (thus, despite repeated listening to a piece, irregular events still elicit emotional effects). Irregular (unexpected) chord functions evoke skin conductance responses, and the amplitude of such responses is related to the degree of unexpectedness.^{32,33} Moreover, unexpected chord functions evoke activity changes in the superficial amygdala (SF)³⁴ and lateral OFC,^{35,36} and activity in the SF and lateral OFC correlates with ratings of felt tension while listening to pieces of classical piano music.³⁷ Note that not all kinds of unpredicted events evoke such emotional effects (e.g., random chaotic stimuli usually do not evoke surprise). (5) A structural breach is usually followed by a transitory phase leading to the resolution of the breach. If a structural breach is not resolved, the musical information is perceived as unpleasant and

arousing.³² Breaches of expectancy give rise to the anticipation of an emotion (e.g., anticipation of the relaxation related to the return to the tonic).²⁸ Similar anticipatory processes can also be evoked by structural cues without a preceding structural breach, for example, by a dominant seventh chord (which has a markedly high probability for being followed by a tonic, thus evoking the anticipation of release). Such anticipation of relaxation might involve dopaminergic activity in the dorsal striatum.^{34,38} (6) The resolution of a sequence (e.g., in tonal music, by returning to the tonic)^{25,27} is associated with relaxation and thus presumably with feelings of reward.³¹ The structural factors mentioned build a tension arc (e.g., buildup, breach, transitory phase, and resolution). (7) The overlap of several tension arcs leads to large-scale structures, and the maximum amount of relaxation due to the processing of intramusical structural relations is reached when all tension arcs are closed at the end of a piece. The degree of tension evoked by intramusical structure and the development of tension and release due to the composition of interwoven tension arcs form an important aspect of the aesthetic experience of music.

With regard to MT, in the “guided imagery and music” method,³⁹ the evocation of tension and resolution by tension arcs as in the tension/resolution patterns of Western tonal music are taken to “enhance the rhythmic balances desired in good health” and the “wide dissemination of sound phenomena throughout the body.” Empirical research is needed, however, to substantiate these hypotheses.

Imagination

The principle of imagination refers to emotional effects of being resourceful, inventive, curious, or creative, and to emotional effects of trying something out. Note that, in contrast to the emotion principles described in the previous sections, imagination requires deliberate, conscious activity. Imagination also refers to emotional effects of the playful act of imagining that what was perceived in the music (e.g., a narrative) would actually be true. Imagining objects (such as monsters) during fear-evoking music enhances fear responses, or imagining oneself in a situation with a particular emotional quality might enhance this emotion (e.g., imagining oneself being happy, heroic, or successful). Similarly,

imagining other individuals (e.g., a couple dancing together to the music) can evoke emotions that are stronger than those felt when listening to the music without imagery or when imagining a scene without listening to music. Some individuals also report that imagination of nature, such as of mountains or fields, enhances their emotional responses to music (see also Juslin’s principle of “visual imagery”).³ Levinson also mentions that imagining to have the emotional expressivity of a musical piece, or the emotional spontaneity, or the emotional spectrum (or richness) expressed by a piece are among the major routes by which (particularly sad) music evokes emotions.⁴⁰

In the guided imagery and music method,³⁹ music-evoked images of a client (or patient) are used (with the aid of a therapist, the “guide”) to cope with inner conflicts and traumata.

Understanding

Emotional effects also arise from understanding. With regard to music, an individual might understand the extramusical meaning of a piece (including the emotion expressed by the music) or the (intramusical) meaning of a musical structure. With regard to the tension arc, the understanding of a musical sequence after a structural breach once it is resolved might lead to an “aha moment.” That is, similarly to a brainteaser, a structural breach can be perceived like a tricky problem that individuals want to resolve (interestingly, we use the word “resolve” with regard to both tension and a problem). Understanding the resolution of a musical sequence leads to feelings of reward and fun. On a larger scale, music analysis deals with understanding the structure of entire pieces with regard to motives, themes, variations, developments, harmonic and melodic structure, rhythmic structure, relations between motives and themes, and other matters. Again, understanding the intricate structure of musical pieces provides feelings of reward and pleasure. Perlovsky argued that humans (and perhaps other species as well) have an inborn need to understand (or “make sense of”) how elements of contexts or structures are synthesized into coherent entities (he refers to this need as the knowledge instinct).⁴¹ The fulfillment of this need to understand is experienced as rewarding (the “aha moment,” or “eureka moment”) and presumably involves activity of the dopaminergic

reward pathway, although this remains to be specified empirically (Zatorre⁴² describes details on neural correlates of music-evoked feelings of reward).

Social functions of music

Music is an activity involving several social functions. The ability and the need to engage in these social functions are part of what makes us human, and the emotional effects of engaging in these functions include experiences of reward, fun, joy, and happiness. Exclusion from engaging in these functions has deleterious effects on health and life expectancy.⁴³ These functions have been reviewed elsewhere¹¹ and are only briefly enumerated here. (1) When individuals make music, they come into contact with each other. Social contact is a basic need of humans, and social isolation is a major risk factor for morbidity and mortality.^{43,44} (2) Music automatically engages social cognition such as figuring out intentions, emotions, desires, and beliefs of other individuals (also referred to as mentalizing, adopting an intentional stance, or theory of mind). Such processes of social cognition are associated with activity of the anterior frontomedian cortex, temporal poles, and the superior temporal sulcus.⁴⁵ Interestingly, individuals with autism spectrum disorder (ASD) seem to be surprisingly competent in social cognition in the musical domain (in striking contrast to their problems with social cognition in other social contexts).^{46,47} This supports the notion that MT can aid the transfer of sociocognitive skills in the musical domain to nonmusical social contexts in individuals with ASD.⁴⁷ (3) Engaging with music can lead to empathy, and I have suggested the term *co-path*y to refer to the social function of empathy: individuals of a group can be empathically affected in a way that interindividual emotional states become more homogeneous (e.g., reducing anger in one individual, and depression or anxiety in another). Co-pathy appears to decrease conflicts and to promote group cohesion,⁴⁸ to increase the well-being of individuals during music making or during listening to music,⁴⁹ and to be important for the emotional identification of individuals with particular lifestyles, subcultures, ethnic groups, or social classes.⁵⁰ (4) Music involves communication (see, e.g., Refs. 51 and 52 for studies reporting overlap of the neural substrates and cognitive mechanisms underlying the

processing of music and language). For infants and young children, musical communication during parent–child singing appears to be important for social and emotional regulation as well as for social, emotional, and cognitive development.^{53,54} Because music is a means of communication, active MT can be used to train skills of (nonverbal) communication. (5) Music making also involves coordination of actions. This requires individuals to synchronize to a beat and to keep a beat. Children as young as 2½ years synchronize more accurately to an external drumbeat in a social situation (i.e., when the drumbeat is presented by a human play partner) compared with nonsocial situations (when the drumbeat is presented by a drumming machine or via a loudspeaker).⁵⁵ This effect might originate from the pleasure that emerges when humans coordinate their movements with each other^{48,56,57} or to a musical beat.⁵⁸ The capacity to synchronize movements to an external beat appears to be uniquely human among primates, although other mammals and some song birds might also possess this capacity.⁴ Synchronization of movements while playing a beat increases trust and cooperative behavior in both adults⁵⁹ and children.⁶⁰ Performing identical movements also gives rise to a sense of group identity. (6) A convincing musical performance by multiple players is possible only if it also involves cooperation. Cooperation implies a shared goal as well as shared intention, and engaging in cooperative behavior is a source of pleasure (associated with activation of the nucleus accumbens (Nac)).⁶¹ Cooperation between individuals increases interindividual trust and the likelihood of future cooperation between these individuals.⁶² (7) As an effect, music leads to increased social cohesion of a group.⁶³ Humans have a “need to belong,” a need to feel attached to a group, and a strong motivation to form and maintain enduring interpersonal attachments.⁶⁴ Meeting this need increases health and life expectancy.^{43,44,65} Social cohesion also strengthens the confidence in reciprocal care (see also the caregiver hypothesis),^{53,66} and the confidence that opportunities to engage with others in the mentioned social functions will also emerge in the future. Note that regenerative effects of music due to engaging in social functions only emerge in the absence of violence. Therefore, W.A. Siebel posited that social functions are inherently linked to experiences of beauty and thus to aesthetic experience.⁷

A note on entrainment

Rhythmic entrainment is “a biological mechanism synchronizing body oscillators to external rhythms, including music.”⁶⁷ However, although it is highly plausible that every emotion involves a synchronization of biological systems involved in that emotion, it is unclear why simply the entrainment of biological oscillation(s) to an external isochronous pulse should evoke an emotion. Perception of the temporal properties of external stimuli is a natural, sufficient condition for the entrainment of brain oscillations, without any apparent emotional component. Even more critically, there is hardly any evidence for music evoking a “synchronization of body oscillators.” For example, although the presence of musical stimuli compared to silence has clear effects on heart rate,⁶⁸ there is no empirical evidence showing that (moderate) differences in tempo have any effect on heart rate or breathing rate (note that large differences in tempo are associated with differences in arousal, which in turn has effects on heart rate and breathing rate).

Therefore, although synchronization and coordination of movements to music among individuals is a very potent principle of evoking emotions (see the section “Social functions of music”), it seems necessary to await clear evidence for emotional effects of entrainment of body oscillators before considering entrainment as a principle underlying the evocation of emotion with music.

Research on emotion principles

Although different emotion principles have been described in the previous sections, it is important to note that, during real-life musical experiences, multiple emotion principles are usually at work at the same time. Especially, “emotional peak moments,” such as musical frissons or music-evoked tears, are probably evoked by several principles at the same time. Therefore, it is difficult to tease apart emotional effects evoked by different principles, hampering research on the emotion-evoking mechanisms, or principles enumerated earlier. This might be one reason why only few studies have so far specifically investigated principles underlying the evocation of emotion with music, with the exception of the intramusical emotion principle of expectancy (or tension/resolution).^{25–27,32,33,37,69–71} To my knowledge, only two studies have addressed

emotional contagion with music,⁸ and only two studies have directly addressed the issue of disentangling effects elicited by different emotion principles.^{8,9}

Conclusions

The framework presented here is a starting point for a systematic, coherent, and comprehensive theory on music-evoked emotions. Several of the principles and subprinciples underlying the evocation of emotion with music (with regard to both music reception and music making) have not been investigated empirically yet, which should give rise to numerous future studies. One challenge of such studies is to provide information on isolated principles, although in real music-listening experience, several emotion-evoking principles are usually active at the same time.

Conflicts of interest

The author declares no conflicts of interest.

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