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MUSIC AND COGNITIVE PROCESSING OF EMOTIONS: INDIVIDUAL DIFFERENCES AND PSYCHOPATHOLOGY

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ABSTRACT

It is a fact: music is all around us. To this date, explanations for how (or why) music exists, how it influences our emotional life, and why it has such an important presence and influence in human environment are yet to be advanced. In this chapter, we will overview the actual knowledge of the interaction between music and emotions. In the following parts, we will define different reasons of how music may elicit emotion, and we will describe the cognitive processes that music brings forth in people. Further, we will present some historical aspects of music and emotion; then we will focus on the similarity of musical and emotional languages and see how this might enable one language to echo the other. Next, we will propose different possible theoretical explanations for the emotional impact of music. Thereafter, we will enlarge on the place music takes during the cognitive processing of emotional stimuli and environment. Finally, we will discuss how emotion identification could benefit from the use of music. Furthermore, we will point out the potential efficiency of music as a therapeutic tool in clinical populations with the objective of developing emotional communication and affective flexibility.

INTRODUCTION

Most people are exposed to music every day, whether it is voluntary (e.g., MP3 player, concerts) or not (e.g., musical background in shopping centres, train stations, neighbour's party). Therefore, it is not surprising that music holds an important part in our human lives. Moreover, current technology allows us to access music wherever and whenever we want.

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This ubiquity of music arises out of considering a few historical aspects of music too. Music is known since the dawn of mankind. Flutes, which are older than 35,000 years, witness to a musical practice as old as Neanderthal ages (Conard, Malina & Münzel, 2009). During his work on the origins of music, Thompson (2009) describes possible evolutionary importance of music for humans. He focuses on several reproductive and survival benefits of music (e.g., benefits for social bonding and the mother-infant relationship).

Most people will agree that music has the powerful gift to convey emotions. As well as music, emotion is known as an omnipresent human phenomenon. People are confronted with emotions every day. Since the beginning of human history, they are crucial to survival. Emotions inform us about our relation to the world and they facilitate our actions. Furthermore, they support our decisions and are necessary to an efficient adaptation to the environment. Despite the infinity of emotional diversity, six basic emotions have been pointed out in emotion research (i.e., happiness, anger, fear, sadness, surprise, and disgust). Emotional communication is the most basic and the fastest of all human types of communication. However, emotions are very complex information to deal with, which require well-developed emotional competencies (i.e., the capacity to identify, understand, express, regulate, and use emotion) (Petrides & Furnham, 2003).

Nowadays, music is used in a variety of ways. Most importantly, the popularity of music can be attributed to its emotional component (e.g., the power of music changes/improves emotional states) and to its social aspects (e.g., the capacity of music to counteract the feeling of loneliness). In 1956, Meyer postulated that the main objective of music was to convey emotion. As a matter of fact, listening to music is reported as the second most used emotional regulation tactic (Van Goethem & Sloboda, 2011). People use music in everyday life, for example, to change their emotional state, to have company, or to anticipate an emotional state while expecting a special “affective” event (Sloboda, Lamont & Greasley 2009). Besides, music is often used to regulate one’s emotions. More than others, adolescents consciously choose specific music in means of emotion regulation and this technique is often carried on through adulthood (Saarikallio, 2010).

Continuously, people are confronted with their own emotions, or more precisely with specific combinations of cognitions, biological changes, and action tendencies. These are the most important cues one relies on in order to identify one’s own emotional state. In a second place, people have the possibility to show, consciously or not, their emotions coming from their inner body (Scherer, 2001).

Furthermore, people are embedded in an emotional environment and have to be able to identify the emotional dimension of the situations they live in. The emotions of others can be identified through verbal and non-verbal communication (faces, body postures, vocalizations, and prosody). Researchers agree that an important amount of emotions is conveyed by non-verbal cues (Manusov & Patterson, 2006). Being able to identify these communication cues is a crucial capacity to discriminate emotions in the most useful way (Mayer, Salovey, Caruso & Sitarenios 2001). Every basic emotion has a typical expression pattern in faces, body, and voice. For example, people are able to systematically recognize emotional meaning through vocal prosody (Scherer, Johnstone & Klasmeyer, 2003). Besides, emotional prosody seems universal as it is equally recognised throughout different languages and cultures (Scherer, Banse & Wallbott, 2001). The vocal dimension of communication is strongly linked to music. Indeed, speech prosody includes the exact features that have been demonstrated in music, such as vocal rhythm, pitch, melody, tempo, and volume as part of non-verbal information (emotional and attentional). As a consequence, Palmer and Hutchkins (2006) propose to describe the musical expression of emotions as musical "prosody". In addition, changes in prosody features are known to provoke different emotions. For example, happy music is characterized by elevated rhythm, high pitch, melody in major key, fast tempo, and loud volume, whereas sad music is expressed in low rhythm and pitch, melody in minor key, slow tempo, and low volume. Interestingly, the emotional meaning of both speech prosody and music can be recognized in different cultures (Scherer et al., 2001; Fritz, Jentschke, Gosselin, Sammler, Peretz, Turner, Friederici & Koelsch 2009).

To illustrate the interdependence of music and emotional prosody processing, the concept of congenial amusia has been introduced. Amusia is characterized by a deficit of pitch perception. Firstly, amusic people show differences in the morphology of the inferior frontal cortex and the superior temporal areas, which are generally activated in pitch perception (Hyde, Lerch, Zatorre, Griffiths, Evans & Peretz, 2007; Hyde, Zatorre, Griffiths, Lerch & Peretz, 2006). Further, some reported behavioural manifestations are difficulties with singing in tune, responding rhythmically to music, detecting pitch errors in melodies, and recognizing melodies without lyrics (Stewart, 2011). Thompson, Marin and Steward (2012) found out that individuals with *congenial amusia* also showed a deficit in emotional communication (i.e., recognition of speech prosody). In this study, amusic individuals were significantly worse than matched controls at decoding emotional prosody with differences among discrete emotions. Therefore this study proved that this deficit is not only reduced to musical content, but also extends to other means of audio emotional communication. In other words, it emphasises the overlapping processes involved during the processing of both music and prosody (voices). Amusic patients also reported difficulties in understanding emotional prosody in their daily lives, suggesting some awareness of this deficit. More precisely, the findings support theories proposing a common evolutionary link between these domains. From this view, music and language share common mechanisms that trigger emotional responses to similar acoustic attributes.

Although research has started to investigate the effects of music on the cognitive processing of emotions, a coherent theoretical framework is still lacking. In the following sections, we will present the current explanations of the emotional influence of music. We will first describe some possible underlying mechanisms of emotion induction with music. Thereafter, we will present different studies about the influence of music as a cue for emotion processing. Finally we will touch on specific impairment of emotion processing in psychopathology and the beneficial contribution of music for therapy.

MUSIC ELICITS EMOTION: UNDERLYING MECHANISMS

Despite the relative poverty of the current theoretical framework of emotions in music, some interesting observations have emerged from the literature in the past few years. Among these, the theoretical model for emotion eliciting through music of Juslin and Västfjäll (2008) is particularly innovative and interesting. According to their model, six mechanisms underlie the induction of emotions through music listening: (1) brain stem reflexes, (2) evaluative conditioning, (3) emotional contagion, (4) visual imagery, (5) episodic memory, and (6) musical expectancy.

Firstly, the *brain stem reflex* refers to a process whereby an emotion is induced by music because one or more fundamental acoustical characteristics of the music are identified by the brain stem as “interesting” or “novel” (i.e., emerging from a potentially important or dangerous element in the environment), which triggers a neural response in the limbic system (e.g., amygdala). Generally, the perceptual system is constantly scanning its environment in order to detect important events or changes. More precisely, some acoustic qualities, representing change (e.g., very loud or fast sounds), lead to an activation of the central neural system (CNS). The brain stem areas play a crucial role in the regulation and allocation of attention toward environmental stimuli by inducing fast activations of the CNS. Interestingly, brain stem responses to speech and music have also been shown to be faster and more intense in musicians than in non-musician controls (Musacchia, Sams, Skoe & Kraus, 2007). Thus, one could infer that the speech-music interaction occurs at an early level of processing. This first and unconscious mechanism can be linked with some neuroimaging findings. Indeed, several studies confirm that the perception and production of music require the activation of a wide range of neural networks typically involved during the integration of afferent stimuli coming from different sensory channels (auditory, tactile, visual) with, for instance, motor outputs, memory, and emotions (Merret & Wilson, 2012).

Moreover, neuroimaging studies demonstrated that listening to music activates affective responses and an interconnected network of subcortical and cortical brain regions. These include the nucleus accumbens, the amygdala, the insula, the hippocampus and hypothalamus, the anterior cingulated and orbitofrontal cortex, the ventral medial prefrontal cortex and ventral striatum (Menon & Levitin, 2005). These brain regions are typically involved during emotion processing in faces and voices as well as in emotion regulation (Phan, Fitzgerald, Nathan, Moore, Uhde & Tancer, 2005; Phan, Fitzgerald, Nathan & Tancer, 2006). This may explain why music takes such an important part in people’s emotional life. Merrett and Wilson (2012) found further neuronal changes in means of higher neural cross-modal integration (of motor and sensory cortices) in trained musicians. It has been reported that the sensory and motor regions of musicians appear to be more strongly linked to each other for several sensorimotor activity than similar regions in non-musicians. Furthermore, Chapin, Jantzen, Scott Kelso, Steinberg and Large (2010) showed that musicians listen to music differently, exhibit different activation patterns during music perception, show enhanced processing of affective vocal sounds, and even show a brain anatomy that is partially different from that of non-musicians. Musically experienced listeners showed increased activation (compared to inexperienced listeners) in ventral striatum, basal ganglia (lentiform nucleus, putamen), subcallosal gyrus, and left ventral anterior cingulated. Moreover, they showed enhanced neural responses related to emotion and reward when compared to inexperienced participants. These results suggest that musical involvement may lead to increased neural responses, or, alternatively, enhanced emotional responding to music may lead one to seek out musical activities. The evidence of neurological changes through music has been illustrated above and the presented findings confirm that listening to music can already change brain functioning advantageously. Särkämö and Soto (2012) proposed that enhanced neural plasticity might be a potential mechanism explaining the beneficial support of music for the cognitive recovery after stroke.

Secondly, the mechanism of *evaluative conditioning* describes that an emotion is induced by a piece of music, for example, because this stimulus has been repeatedly paired with a positive or negative event. Thus, for instance, a particular piece of music may have occurred repeatedly together in time with a specific event that always made you happy (e.g., meeting your best friend). Over the time, the music takes the emotional meaning of these situations and can evoke pleasant feelings even without meeting your friend.

Thirdly, the mechanism of *emotional contagion* refers to a process whereby an emotion is induced by a piece of music because the listener perceives the emotional expression of the music, and then "mimics" this expression internally, which leads to an induction of the same emotion. This mechanism seems to be strongly linked to mood congruency. Given that music influences emotional states and that emotional states influence the encoding of information, music may also have an influence on emotion encoding. To investigate how this influence of music is characterized, Tesoriero and Rickard (2012) integrated the emotional arousal theory, the mood congruence theory and the functional theory for a comparison in research design. The emotional arousal theory suggests that the effect of emotional states on memory is mediated by neurobiological mechanisms that accompany emotional arousal. The mood congruency theory suggests that the effect of emotional state on encoding is a result of congruence between the emotional state of the participant and the information presented. The functional theory suggests that the effect of mood on cognition can also depend on processing strategy. As mentioned, positive mood leads to more heuristic processing with open, creative, and inclusive processing solutions, which favour automaticity, while negative mood leads to more systematic and analytic processing strategies. It has recently been confirmed that negative mood reduced the automatic processing of affective words and that positive state influence attentional processes beneficially (Vermeulen, Corneille and Luminet (2007; Vermeulen, 2010). In the study by Tesoriero and Rickard (2012) the participants were asked to listen to music and different emotional narratives, and to afterwards freely retell the stories listened to. Results show that the facilitation effect of music is best explained by the congruence between the emotional valence of music and the emotional valence of the story. No effects have been found for the emotional arousal theory or the functional theory.

The fourth mechanism is *visual imagery*, which refers to the idea that an emotion is induced in a listener because he calls up visual images (e.g., of a beautiful landscape) while listening to music. The emotions experienced are the result of a close interaction between the music and the images. A special feature of the imagery is that the listener is able to influence the emotions induced by the music.

In the fifth place the mechanism of *episodic memory* is presented. This refers to a process whereby an emotion is induced in a listener because the music evokes, consciously, a memory of a particular personal event in the listener's life (e.g., your best friend's wedding). This emotion can be very intense, perhaps because the physiological pattern of the original event is stored in the memory as well.

The last presented mechanism, *musical expectancy*, explains the process where an emotion is induced in a listener because a specific feature of the music violates, delays, or confirms the listener's expectations about the continuation of the music. Like language, music consists of a certain structure and rules. Although, this capacity to discriminate a certain musical structure needs some learning that often occurs naturally through cultural development and education. Even without musical education, this learning might be possible through the similarities of music and prosody.

In parallel with the elaboration of the above-presented framework about the underlying mechanisms, members of this research group investigated the use of music in everyday life through an experience sampling method (ESM). This methodology means that participants were asked several times a day during a week to respond immediately to a set of questions about the situation and a possible use of music. During that survey, the researcher asked people to identify which of these mechanisms caused their emotional feeling while they were listening to music. The participants reported most frequently emotional contagion (32%) and brain stem response (25%), then episodic memory (14%), visual imagery (7%) and evaluative conditioning (6%), and finally the lyrics (4%) or musical expectancy (4%) as causes of the influence on their emotions (Juslin, Liljeström, Västfjäll, Barradas & Silva, 2008).

As we saw for musical expectancy, people need a natural learning process to integrate a complete concept of *emotion,* too. Barrett (e.g., Barrett, 2006; Barrett, 2009) proposed that individuals differ in the "granularity" (previously called *emotion differentiation*) of their emotion concepts: they observed that when asked to describe everyday-life experiences, some people make categorical distinctions and use discrete emotion terms while others do not. So, persons with lower emotional granularity perceive affective states as broad and undifferentiated categories with low specificity, whereas those with higher granularity perceive more precise and differentiated emotional states. They also propose that emotional granularity can be trained, much as wine experts have been trained to perceive subtle differences that novices are unaware of. Analogously, musicians might develop sharper (granular) emotion concepts for music because an important part of their training and professional activity as performers or teachers concerns the expression and perception of subtle modulations in musical expressivity. Because the acoustic codes of emotions are similar in music and speech (Juslin & Laukka, 2003), musicians might rely on their finely grained concepts for musical emotions when perceiving emotional speech.

Generally, the expression of an emotion in music can be recognized very fast (Bigand, Filipic & Lalitte, 2005). It is likely that the recognition of a certain emotion also activates other concepts associated with that emotion (i.e., the expression of sadness in music will automatically lead to the activation of concepts such as funeral or separation which are associated with the recognized emotion). The co-activation of related concepts suggests that recognizing an emotion in music could have an effect on the processing of emotional information in other domains, such as language, which is coded in semantic form (i.e., through the meaning of the word). Let us illustrate this by an example. A situation can have a general emotional component that will activate or prime a prototypical script. Imagine you are entering a cathedral to visit it and before you can see the people next to the altar, you hear either *Adagio for strings* by Samuel Barber or Mendelssohn's *Wedding march* from *A Midsummer Night's dream*. Already this musical sound will activate the concept of a funeral or a marriage and can put a person into a congruent emotional state.

Furthermore, a complete concept of emotion can be obtained through optimized emotional competencies, also better known as emotional intelligence (Mayer et al., 2001). To be able to correctly deal with emotions, people need different elaborated emotional competencies. First of all, people have to be able to perceive and identify an emotion (in oneself and others). Furthermore, they need to understand the emotion (why it occurs and what its consequences are). Also, people should be able to express their own emotions and give others the possibility to express their emotions as well. Finally, an adequate regulation and use of emotions is requested for a positive adaptation to people's emotional environment.

In the following part of this chapter, we will mainly focus on the influence of music on the identification of emotions, known as a very basic emotional competency (Mayer et al., 2001).

MUSIC AS A CUE FOR EMOTION PROCESSING

In everyday-life, people experience situations and the emotions conveyed in a cross-modal way by constantly integrating information from different modalities (visual, auditory, olfactory, tactile). Different researchers have started to work on the cross-modal integration of emotion (i.e., binding emotions from visual and auditory modality). They suggest that cross-modal emotional stimuli lead to a better emotional categorization performance in comparison to unimodal stimuli (Föcker, Gondan & Röder, 2011; Collignon, Girard, Gosselin, Roy, Saint-Amour, Lassonde & Lepore, 2008). Indeed, in the case of visual/auditory cross-modality, people process emotions with their visual and auditory cortices simultaneously so that the early sensory stages of processing are boosted and a cross-modal facilitation effect appears (Brosch, Grandjean, Sander & Scherer, 2008). This cross-modal facilitation effect is usually characterized through faster encoding and higher accuracy rates. Moreover, people can perceive an emotional state in others through different visual (i.e., face, body posture) and auditory (i.e., vocalizations, speech prosody) cues. In previously conducted studies, body postures, emotional facial expressions, prosody, music, and words have been used in cross-modal combinations (Vermeulen, Toussaint & Luminet, 2010; Goerlich, Witteman, Aleman, & Martens, 2011; Stienen, Tanaka, & de Gelder, 2011; Dolan, Morris, & de Gelder, 2001).

Referring to the emotional power of music and its similarities to emotional prosody, some researchers have started to examine the influence of music on the automatic processing of emotions. Graham, Robinsons, and Mulhall (2009) investigated the influence of music on automatic emotion treatment using an emotional Stroop task. In the classic colour Stroop task, the participants have to name the font colour of presented words (e.g., colour words or object words). The Stroop effect proves the difficulty to inhibit the urge to name (i.e., to read) the colour word (e.g., the word RED) instead of the font colour and appears through longer response times for colour words than for other target words (Stroop, 1935). The emotional Stroop effect has been found stronger for the colour naming of negative words than for neutral words (i.e., longer mean response time). In Graham et al.'s (2009) study, the participants were listening to happy music while undertaking an emotional Stroop task. The previously described Stroop effect was present under silent conditions, but listening to music moderated this effect, and the expected interference (i.e., expressed through longer response time) was significantly diminished. The authors suggest that this effect could, for example, be explained by an altered attentional state associated with concurred task irrelevant stimuli or by changes in physiological arousal and emotional state. Finally, they pointed out to the neural bases of the process and the importance of the amygdala.

Furthermore, some researchers started also to introduce cross-modal paradigms in affective priming, more precisely the auditory/visual cross-modal facilitation effect of *music* on the identification of emotions. Sollberger, Reber and Eckstein (2003) mentioned that emotional words were evaluated faster when preceded by an affectively congruent chord rather than an incongruent one. They used randomly matched consonant/dissonant musical chords with positive/negative valence words. The participants were told that an acoustic signal would introduce the appearance of the target. The authors controlled for the participants' awareness of the hypothesis as well. To avoid any influence of density of chords, the researchers in a second experiment only used chords with the same number of notes. In Experiment 2, the affective priming effect of Experiment 1 was replicated. Again, target words were evaluated faster when preceded by an affectively congruent chord rather than an incongruent chord, independently of whether participants were aware of the tested hypothesis. Further, Steinbeis and Koelsch (2010) found out that dissonant/consonant, major/minor, and unpleasant/pleasant chords have an impact on the categorisation of emotional words. In their study, congruent primes let the participants rate the stimuli faster (e.g., pleasant chords - baby). To test the hypothesis according to which emotion that can be expressed by various musical components can convey information that is likely to influence the processing of meaning, several cross-modal priming experiments were conducted. Similar to semantic priming studies, single chords were followed by target words which either did or did not match the affect communicated by the chord. It was found that target words matching the preceding chord in valence were evaluated faster than mismatched target words. In addition, Event-Related Potentials (ERP) results showed an increase in the N400 (i.e., a semantic Event-Related component) amplitude in response to mismatched target words.

Vermeulen, Toussaint and Luminet (2010) also used an affective mind-set priming paradigm by presenting classical music pieces as background sound. In this study the musical context was irrelevant for the main evaluation task. The music was slightly spread in the room while the participants completed a word evaluation task. They reported the same congruent emotional facilitation effect, i.e., participants showed a better performance for happy target words in happy music condition and for angry target words in angry music condition. Additionally to these findings, Weisgerber, Constant, Gilson and Vermeulen (in preparation) used classical and contemporary music pieces, but cut them to short primes of 1500 milliseconds. Different to the previous presented studies, we used emotional facial expressions (EFE) as targets. We found that people were faster and more accurate to identify the emotional content of the facial expressions when there was an emotional match between the prime and the target.

Most multisensory research was limited to facial and vocal expressions. Van den Stock, Peretz, Grèzes and de Gelder (2009) realized a similar study but they integrated music and the emotional recognition of body postures. The results show that recognition of body language is influenced by the auditory stimuli. Happy body postures are evaluated as happier when presented with happy music than with sad music or without any music at all. These findings indicate that cross modal influences can also be obtained from the ignored auditory to the attended visual modality in audio-visual stimuli that consist of whole bodies and music. The importance of the present findings lies in the fact that even multimodal inputs with no direct strong adaptive association can modulate the affective interpretation of clearly separate information streams. Nevertheless, instrumental music and body movements certainly occur frequently in dance, movies, social situations, etc.

Most studies using audio-visual integration of emotional stimuli, including the above-presented studies, investigated the influence of auditory stimuli on the evaluation of visual stimuli. Thompson, Russo and Quinto (2008) were the first to use a different kind of audio-visual integration of emotion and investigated how emotional faces influence the recognition of emotional cues in songs. They found out that the congruent emotional face facilitates the perception of emotion in music. Emotion perception for music performances is a multimodal phenomenon in which emotion cues from different perceptual systems are automatically and preattentively combined to form an integrated emotional interpretation. In line with these results, Vines, Krumhansl, Wanderley, Dalca and Levitin (2011) showed that seeing a musical performance enhances the perceived emotional expressiveness of that performance compared to situations in which participants only listen to music. But it still remains to be clarified if and which modality has a greater impact to facilitate cross-modal emotion identification.

The studies described above investigated the effect of listening to music on the processing of different emotional visual stimuli (words, faces, body postures). A slightly different research domain works on the influence of musical experience (instrumental training) on the capacity to identify emotion in speech prosody. This research combines two different emotional auditory stimuli.

Thompson, Schellenberg and Husain (2004) investigated for example if music training in childhood has an impact on people's capacity to identify emotions in speech in adult age. In Experiment 1, adults who had taken music lessons during their childhood were better than untrained adults at identifying the emotions conveyed by sound sequences that mimicked the prosody of spoken utterances. In Experiment 2, musically trained adults were better than untrained ones at identifying sadness and fear conveyed by utterances spoken in both familiar (English) and unfamiliar (Tagalog) languages, and by prosody mimicking tone sequences. Musically trained adults were also better at identifying spoken utterances with emotionally neutral prosody. In Experiment 3, the authors investigated if there was a difference between children taking music lessons and a control group. Children (seven years old) were asked to identify the emotions conveyed in speech or in tone sequences. For fearful–angry comparisons, children who took keyboard lessons during the previous year performed equivalently to children with drama lessons but better than children with no arts lessons. The equivalence between keyboard and drama lessons is particularly noteworthy because the drama lessons focused specifically on training the speaking voice and the use of prosody. These results suggest that training in music may engage, refine, and develop skills used in associating pitch and temporal patterns with emotions. Besides, Experiments 2 and 3 controlled for intelligence (e.g., Raven Matrices and WISC-III), but the authors did not observe any differences regarding the general intelligence score. In Mayer et al.' s (2001) view, the ability to perceive emotions is the most basic component of emotional intelligence. Thompson et al.'s (2004) results suggest that development of this basic component can be facilitated through training in music. Trimmer and Cuddy (2008) tried to replicate this previous study, but in contrast to Thompson et al. (2004), they did not observe any effects of musical training on the recognition of emotional prosody in adulthood.

With respect to these previous studies, Lima and Castro (2011) introduced some important differences in the procedure. First, they included a wider range of emotions (i.e., including the six basic emotions: anger, disgust, fear, happiness, sadness, surprise and neutrality). Second, the stimuli underwent perceptual and acoustic validation, so that it was known previously that they effectively conveyed the intended expressions. Third, they introduced two additional measures, reaction times (RTs) and intensity ratings. Fourth, participants were chosen from two age groups, young and middle-aged adults, in order to verify whether the possible effect of expertise would be general and long lasting, too. Finally, apart from general intelligence, participants were also assessed for personality and socio-communicative traits because these may influence emotion processes. In this study, music training was investigated as a facilitator to enhance the ability to identify emotional prosody. An effect of expertise was found, i.e., musicians were more accurate than controls, similarly across emotions and age groups. This effect cannot be attributed to socio-educational background, general cognitive or personality characteristics, because these did not differ between musicians and controls. Perceived intensity of prosody and response times was also similar in musicians and controls. Furthermore, basic acoustic properties of the stimuli like fundamental frequency and duration were predictive of the participants' responses, and musicians and controls were similarly efficient in using them. These results indicate that emotional processing in music and in language engages shared resources.

EMOTION PROCESSING IN MUSIC: IMPAIRMENTS IN PSYCHOPATHOLOGY

It is acknowledged that nearly 75% of mental disorders involve deficits in emotional processing and emotional regulation (Kring and Sloan, 2010). To this date, little research has been undertaken to investigate whether the deficit in emotion perception is present for music as well, but a few studies observed that a deficit of emotion processing in music was substantiated in some psychopathological disorders. These few studies aimed at investigating the impairment of emotion processing in faces, prosody, and music in psychological disorders like depression, alcoholism, and schizophrenia.

The development of emotional competences appears to be different in each individual and some people show more deficits than other. Alexithymia[1], for example, is a multifaceted construct, which encompasses difficulties in identifying and expressing emotions and has been claimed as low emotional intelligence (Taylor, 2001). More precisely, it is characterized by reduced imagination and an externally oriented cognitive style. These impairments seem to influence emotion expression through the autonomic nervous system and generate chronically physiological changes. For instance, in our lab, Luminet, Rimé, Bagby and Taylor (2004) investigated the relationship between alexithymia and different features of emotional response. Participants watched an (non) emotional movie while their physiological responses (i.e., heart rate, blood pressure) were being measured. Afterwards, participants evaluated the content of the movies in a questionnaire. Results show that heart rate was elevated in high alexithymia scorers for the emotional movies. However, in comparison to controls, they rated the movie as less or equally emotional and used fewer emotional words to describe the scene. These results highlight that physiological hyperarousal and the difficulty to describe the emotional experience can influence health. The association of difficulties to describe feelings with increased physiological arousal show, for example, similarities to people with a repressive coping style.

Besides this, an overall deficit in identifying emotions expressed in voice and music has been demonstrated in schizophrenic and depressive patients. Depressive patients having deficits in emotional intelligence evaluate emotional content of music as less intense than depressed patients without deficits in emotional intelligence.

Firstly, Bodner, Iancu, Gulboa, Sarel, Mazor and Amir (2007) examined the effect of four emotionally distinctive types of music (i.e., happiness, fear, anger, and sadness) on patients with *major depressive disorder* (MDD group) and on healthy controls (HC group). Depression is a highly prevalent mood disorder that impairs a person's social skills, their

[1] Alexithymia can be envisaged as a negative counterpart of emotional intelligence. The more people present alexithymic features, the less they are emotionally intelligent.

quality of life and it affects a person's ability to recognize emotions. The used musical pieces were classical pieces (e.g., Beethoven, Stravinsky) and were pretested to evoke a specific emotional feeling. Participants were asked to choose emotional descriptors that expressed the feelings induced in them following each excerpt. Patients with MDD chose less emotional labels than controls in response to angry, scary, and happy excerpts, but they chose emotional labels in response to sad music that were similar to those chosen by controls. So, patients with MDD chose more labels in response to sad music than to any other excerpt. These findings are in line with clinical descriptions stating that patients with MDD show general restrictions in verbalizing their emotions but access sad emotion words easier when cued through music. Naranjo, Kornreich, Campanella, Noël, Vandriette, Gillain et al. (2011) also implemented a study with *depressive patients*. Twenty-three paranoid schizophrenic patients and twenty-three matched controls (for age, gender, and education) participated in the study. All patients had standard antidepressant medication. The authors excluded patients showing comorbidities with bipolar I or II disorder, schizophrenia, organic brain disorder, and substance abuse or dependence reported during 6 months before the study. After clinical assessment and control measures (BDI, STAI-Y, D2), participants had to identify the intensity of emotion of the presented faces (Maurage, Philippot, Verbanck, Noel, Kornreich, Hanak, et al., 2007), voices (Belin, Fillion-Bilodeau & Gosselin, 2008) and musical excerpts (Vieillard, Peretz, Gosselin, Khalfa, Gagnon & Bouchard, 2008) (i.e., happy, peaceful, sad, and scary emotions). The depressed participants demonstrated less accurate identification of emotions than the control group in all three sorts of emotion-recognition tasks. The depressed group also gave higher intensity ratings than the controls when scoring negative emotions, and they were more likely to attribute negative emotions to neutral voices and faces. Their results suggest that all emotional information processing is affected by depression, including modalities, such as music, which are not usually associated with an interpersonal context.

Secondly, Kornreich, Brevers, Canivet, Ermer, Naranjo, Constant et al. (2012) found similar impairments in *alcohol- dependent patients*. They investigated the capacity of emotion identification and recognition in faces (Maurage et al., 2007), voices (Belin et al., 2008) and musical excerpts (Vieillard et al., 2008). Participants were instructed to rate the intensity of several emotions on a scale from 0 for 'absent' to 9 for 'highly present'. Depression, anxiety and sustained/selective attention capacities were controlled for. They found out that alcohol-dependent patients were significantly less accurate than controls in identifying the target emotion in faces, voices, and musical excerpts.

Finally, Weisgerber, Vermeulen, Peretz, Samson, Philippot, Maurage et al. (in preparation) point out that *paranoid schizophrenic patients* show difficulties in the categorization of emotions in faces, voices, and music. In this study, we investigated the capacity of schizophrenic patients to identify emotions in faces, vocalization, and music. Thirty paranoid schizophrenic patients (from three Belgian hospitals) and thirty matched controls (for age, gender, and education) participated in the study. After some clinical assessment and control measures for depression, anxiety, and attentional capacity (respectively with BDI, STAI-Y, and D2), the participants were asked to rate the intensity of emotion in the presented emotional faces, vocalizations, and musical excerpts. We found that the schizophrenic patients were significantly less accurate in the identification of emotions than controls in the three types of stimuli. Interestingly, it seems that the symptomatology plays an important role here. Patients scoring high on the Positive and Negative Syndrome Scale (PANSS) showed greater impairments for the identification of emotions in the three types of stimuli. Although, these results suggest impairments in the identification of musical emotions as well, further research is needed to better understand this deficit of emotion identification in schizophrenic patients.

These three studies used almost exactly the same stimuli for their investigation. Unfortunately, the proposed emotion ratings differed between the different modalities (i.e., face, voice, music). To evaluate the music and the faces, they proposed, for example, cheerfulness, peacefulness, sadness, and worriedness, but to rate the emotional intensity of the voice they proposed anger, disgust, sadness, fear, joy, and surprise. In further investigations, it would be interesting to compare ratings in faces, voices, and music, but this requires uniform evaluation scales.

BENEFITS OF MUSIC FOR PSYCHOPATHOLOGY

As psychiatric disorders show impairments in emotion experience, empirical research started investigating the possible improvement in emotional capacities following music listening in emotional and psychiatric disorders. Some researchers report evidence that music can ameliorate disorder symptoms by provoking a general positive influence. Although music therapy gains ever more importance in health care and treatment, the beneficial effect of music has barely been investigated empirically. In the last part of this chapter we will describe some studies, which investigated the specific influence of music on the identification of emotions in different emotional (involving psychiatric) disorders. Thaut and Wheeler (2010) suggest exploring the potential of music to provide experiences of emotional learning through the identification, the verbal and non-verbal expression of emotion, and the ability to modulate and adapt appropriately emotional behaviour.

As mentioned in the previous section, people show individual differences in emotion handling capacity. Vermeulen et al. (2010) integrated music in the *alexithymia* research domain. Participants were distributed in different musical conditions while they had to accomplish an emotion identification task (i.e., *is this word related to the emotion domain*?). A facilitation effect through congruency of musical prime and word target has been confirmed and discovered for individuals with deficits in emotional intelligence (i.e., alexithymia). Correlations between alexithymia and cognitive processing of emotions in different music conditions confirmed this congruency effect. This means that in the angry music condition participants with alexithymia evaluated more accurately angry words and faces and in the happy music condition more accurately the happy stimuli. Further research is needed to understand whether such musical cues might help psychiatric patients (e.g., schizophrenia, depression) as well as to improve emotion identification.

Mössler, Chen, Heldal and Gold published in 2011 a Cochrane review including eight studies about the effect of music therapy for *schizophrenia* and similar illnesses. They criticized that there is no evidence-documented work for the beneficial help of music for schizophrenic patients so far. All reported studies used a combination of typical music therapeutic techniques: active music making (often improvisation, but also songs) and listening to music. All outcomes were reported for the short term (up to 12 weeks), medium term (13 to 26 weeks), and long term (more than 26 weeks). The reported outcome measures are general symptoms, negative symptoms and functioning (including social functioning).

Mental state was measured considering symptom scores of general mental state (PANSS, BPRS), negative symptoms (SANS), depression (SDS and Ham-D), and anxiety (SAS).

They reported that music therapy showed moderate to large effects on general mental state, negative symptoms, depression, and anxiety. ‘High-dose’ music therapy of more than 20 sessions showed significant effects on all mental state scores. They found a significant effect for ‘high-dose’ music therapy (more than 20 sessions) on social functioning. A large effect on positive behaviour and negative behaviour could be identified. Music as a medium of therapy may address specifically issues related to emotion and interaction, and therefore it seems plausible that music therapy may be particularly well suited to the treatment of negative symptoms. Negative symptoms are related to affective flattening and bluntness, poor social interaction, and a general lack of interest. The reported effects of outcomes were measured over the short to medium term. Music therapy seems to especially address motivational, emotional, and relational aspects, and helps patients reconnect to both intrapersonal and social resources. However, the effects of music therapy seem to depend heavily on the number of regular music therapy sessions, as well as the quality of the music therapy provided (trained music therapists who are skilled in using adequate music therapy methods).

Furthermore, another study specifically investigated the influence of music improvisation on the narration capacity of schizophrenic patients. Interestingly, music improvisation has been shown to help schizophrenic patients improve their ability to make coherent narratives. More critically, the researcher carrying out the study found that music increased positive emotions, decreased negative emotions, and improved affective tone. These results suggest that, similarly, music should also improve emotional competencies generally (Eyre, 2008).

In a study about music therapy in the treatment of *depression*, Erkkilä, Punkanen, Fachner, Ala-Ruona, Pöntiö, Tervaniemi et al. (2011) explained that music therapy is accepted by people with depression and is associated with improvements in clinical states and mood. They concluded that music could be successfully used as a therapeutic tool with depressed patients in order to access emotional feelings (other than sad ones).

Bodner, Aharoni and Iancu (2012) investigated the influence of music training in patients with *social anxiety disorder* (SAD) to identify emotion in spoken language. All participants performed a vocal-improvisation recognition task, and half of them undertook training in happiness recognition in musical improvisation. The four groups (trained SAD, untrained SAD, trained controls, and untrained controls) were then compared regarding the extent of accurate identification of five basic emotions (happiness, fear, anger, sadness, and surprise) in spoken language. Participants with SAD demonstrated less accurate identification of happiness in spoken language as compared to the healthy controls. However, participants with SAD trained to recognize happiness showed an improved ability to identify happiness in spoken language, similarly to healthy controls.

Even though these presented studies suggest a beneficial effect of music on processing emotion, they do not give specification on the different emotional competences (EC, i.e., identifying, understanding, expressing, regulating, and using emotion). However, in our opinion it seems important to further investigate the use of music for a specific EC to find out how music can have an influence at different levels of emotional intelligence and on which of these competences music may have the greatest impact. To elaborate this research area, a conceptual integration of the underlying mechanisms involved during music-evoking emotion and of the emotional competencies construct is necessary.

CONCLUSION

Music has an important unintentional influence on the evaluation of emotional stimuli. By using, for instance, the affective priming paradigm, a facilitation effect was observed when the musical prime (i.e., chords) and the words used for evaluation shared the same emotion (congruence). Furthermore, musicians seem to show a more delicate capacity to accurately identify emotional prosody.

These examples suggest that music is a powerful tool for emotion processing. We illustrated that music serves as an additional cue for the treatment of emotional content. Taking music as an additional form of emotional communication, it could be assigned a specific role to develop and stimulate various emotional competences. We also saw that the reported deficits in emotion recognition in some psychopathological disorders extend to music processing too. Interestingly, however, recent research showed that music could be used as a way to enhance emotional competencies (mainly the identification component) and ameliorate emotional affect as well. These observations suggest that music can help to enhance awareness of emotional information and is an asset to clinical intervention.

Finally, this chapter focused especially on the treatment (identification) of emotions, but further consideration must be undertaken for other emotional competences (e.g., regulation of emotions) as well. The studies illustrated in this chapter still demonstrate an important diversity and lack in research on music and emotion processing, and should be the objective of future empirical research endeavour.

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