Emotional reactions to music

Psychophysiological correlates and applications to affective disorders

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Summary

Music has been used to evoke emotions for centuries. The mechanisms underlying this effect have remained largely unclear. This thesis contributes to research on how music evokes emotions by investigating two mechanisms from the model of Juslin and Västfjäll (2008) - musical expectancy and emotional contagion. In the perception studies the focus is on how musical expectancy violations are detected by either musically trained or untrained individuals. In the music-making studies, we concentrate on mood change brought about by cheerful music in healthy and depressed individuals and factors which could modulate this change like personality, musical preference and general emotional state.

The results indicate that the subtlest scale violations are detected at the level of brain electrical potential while the task remains behaviourally difficult. This suggests that scale information is processed using music-syntactic analysis and in memory existing representations of tonal hierarchies, instead of auditory sensory memory as previously believed.

Music-making decreased anxiety, depression and fatigue in both depressed and healthy participants whereas arousal and positive mood increased. This suggests that music-making could be beneficial for depressed individuals in terms of improving their mood on a short-term basis, even though a reliable music-related decrease of depression symptoms was not found. Among healthy participants, intraversion, openness to experience, agreeableness, musical training and liking of the music predicted positive changes in mood following a music-making session.

Taken together, these studies indicate that subtle musical scale violations are detected even if they are not consciously perceived as deviants and could therefore be used to evoke emotions, and music-making improves the mood in both healthy and depressed individuals and could serve as a temporary relief in case of depression.

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Preface

This thesis was written in the cumulative format, consisting of a collection of studies written in form of papers for publication. The studies are preceded by an overview chapter, which consists of a general introduction, an outline of the studies conducted, a brief summary of the results and a discussion. The aim of the discussion is to connect and integrate the findings of the studies and relate them to the broader background. After the overview chapter, a publication plan is presented for each empirical study included in the thesis, one of which is published, two are under review for publication and two are in preparation to be submitted.

Contents

Chapter 1

Introduction

1.1 General background

Music is part of the daily life for most people, chosen either by themselves or by various others – shop owners, street musicians etc. Music is around us whether we want it or not. Even though music is not a biological necessity like air or water, most people choose to have music in their lives. It has become an undisputed part of many events, such as weddings or funerals. One reason why people are drawn to music and value it highly is its ability to evoke and communicate emotions (Juslin and Västfjäll, 2008; Meyer, 1956). This property of music is deliberately used in movie soundtracks (Cohen, 2001) or in advertising – or by people who choose specific music to accompany them during different activities like exercising, going to sleep etc. with a goal (among others) "to express, release, and influence emotions" (Juslin and Laukka, 2004, p. 232).

Research into music psychology has grown exponentially during the last decades. According to the EBSCO database (16.03.2011), 831 peer-reviewed journal articles devoted to music perception and 109 to music and emotion were published between 1970 and 1990. During the following two decades the number has increased more than threefold for music perception and almost sevenfold for music and emotion. However, the mechanisms underlying the ability of music to evoke emotions and influence physiological functions have moved into the research focus only recently. This change has been facilitated by the available knowledge on music perception, by increased availability of electroencephalography and different imaging methods and motivated by the need for evidence of efficacy of music therapy (Edwards, 2005).

Music therapy, although widely used, has been met with scepticism by the medical circles, as it originated from anecdotal evidence observed at the bedside of wounded soldiers after the World Wars – musicians were invited to cheer them up, and it seemed to facilitate their recovery (de l'Etolie, 2010). Nowadays, this evidence does not suffice anymore and music therapy, in order to be accepted as an effective method of therapeutic intervention, rather than a generic feel-good activity, aspires to become evidence based (Edwards, 2005). To this end, besides knowing that music has the ability to increase well-being (Clift and Hancox, 2001, 2010) and decrease suffering, it is also necessary to know how music is processed, which changes it is able to induce, and how these changes are generated.

This thesis contributes to research on how music evokes emotions by investigating expectancy violations as one of the musical techniques used to evoke emotions, and by testing the usefulness of a novel music-therapeutic application on depressive symptoms, which relies on another one of the emotion evoking mechanisms described by Juslin and Västfjäll (2008) - emotional contagion. If the intervention is proven effective at the behavioural level, it can inform further studies to establish the physiological mechanisms of these behavioural changes and be applied in therapeutic setting to decrease the suffering related to depressive disorders.

The experiments in this thesis can be divided in two main groups. The first two experiments focus on music perception, specifically violation of expectation for a musical scale. The following two experiments examine whether music's ability to elevate mood can be used to decrease the symptoms of depressed patients and the last chapter adds to the previous two the dimension of personality and focuses on the modulating role personality differences can play in how music affects people.

In the first chapter of this thesis, an overview of research into music perception, emotional correlates of music processing in healthy and depressed individuals, and music and personality differences is presented. Next, a short introduction is given to Bayesian inference, which is used in data analysis in one part of this thesis, in order to keep the thesis self-contained. This literature review is followed by an outline of the studies conducted, and the main results. Finally, a general discussion will draw the findings back to the theory and highlight their contribution to research of music and emotion.

1.2 Music perception

Music belongs to auditory stimulation and is partly processed in similar ways to the rest of auditory input – language, for example. Electroencephalography (EEG), thanks to its good temporal resolution, has been widely used to investigate auditory processes, including music. In the following section, an overview of auditory and more specifically music processing is given, along with the neuroelectrical correlates of processing of different aspects of musical stimuli. The review covers also changes in brain plasticity in relation to musical training and musical expectancy in broader sense. This provides background to the studies on musical expectancy, where scale violation processing was investigated and also the personalty and mood study, which additionally looks at the effects of musical training in mood induction. Scale violations represent a type of musical expectancy violation and could therefore be used in compositions to evoke emotional responses in listeners (Juslin and Västfjäll, 2008; Meyer, 1956).

1.2.1 Neural correlates of music processing

Auditory processing

In early processing stages, acoustic information is translated into neural activity in the cochlea and directed to the auditory brainstem (superior olivary complex and inferior colliculus). Next, the signal is further projected from thalamus into the primary auditory cortex, located in the temporal gyrus (Heschl's gyrus and planum temporale), the amygdala and the medial orbitofrontal cortex. In the auditory cortex, the physical features of the sound are extracted (frequency, amplitude, chroma, timbre, and roughness) while amygdala and orbitofrontal cortex are involved in processing of the emotional features of the auditory input and regulation of emotional behaviour (Koelsch et al., 2005). Other auditory-related areas are located in the temporal, parietal and frontal lobes and are concerned with converging auditory, visual and somato-sensory information (Hackett, 2008).

When the sound features are extracted, the processing paths divide and different aspects of the auditory input are processed in different brain areas. Significant part of the evidence here originates from lesion studies, demonstrating that while some aspects of auditory processing are affected by the brain damage, other aspects may remain intact. For example, discrimination of pitch relations could be disrupted while perception of time relations is preserved and vice versa (Peretz and Zatorre, 2005; Peretz, 1990).

For pitch relations, the most important areas are located in the right temporal lobe.

Lesions in posterior right superior temporal gyrus results in the inability to differentiate melodic contours (Peretz and Zatorre, 2005), whereas lesions in the right anterolateral Heschl's gyrus bring about increased threshold for pitch change direction perception (Johnsrude et al., 2000). Parahippocampal gyrus is involved in processing of dissonance (Blood et al., 1999) and lesions in this region result in inability to differentiate between consonant and dissonant musical excerpts (Gosselin et al., 2006).

Rhythmic patterns can be divided into regular (meter, beat) and irregular (grouping) and it is suggested that the right hemisphere is involved in processing meter and left hemisphere is responsible for grouping – people find it easier to tap beat with the left and the rhythmic pattern with the right hand. Moreover, left or right-sided lesions in the anterior part of the superior temporal gyrus result in impairments in rhythmic or meter evaluations respectively (Peretz and Zatorre, 2005). Although damage to the right hemisphere causes more disruption than a lesion on the left, co-operation of both hemispheres is necessary for music processing (Peretz, 1990).

In healthy subjects, activation in frontal operculum and planum polare have been implicated in use of implicit knowledge of harmonic and melodic rules. In contrast, processing of rhythmic patterns is likely to activate lateral premotor cortex, basal ganglia and posterior cerebellum (Brown et al., 2006). Planum temporale plays an important role in processing of pitch intervals and it has been demonstrated that for individuals with the perfect pitch, the left planum temporale is significantly larger (Jäncke, 2001; Schulze et al., 2009; Loui et al., 2011).

The lateralization of music processing can also be influenced by musical expertise. Lesion studies with musicians suggest that the right hemisphere is more involved in music appreciation, whereas the left hemisphere is concerned with detailed processing of musical information in more cognitive ways. Moreover, musicians appear to process melodies predominantly in the left hemisphere while for non-musicians the right hemisphere dominates (Peretz, 1990).

EEG correlates of music processing

Musical processing starts with the extraction of the physical features of the sound (frequency, chroma etc.) in the auditory cortex and is reflected in the EEG by early components with latencies up to 100ms (P1 and N1). Notably, a single sound can already carry meaningful information, for example, sound bright or dull (Koelsch et al., 2005). The sources for N1 are likely to be located at the posterior and lateral Heschl's gyrus (Pantev et al., 2001).

Once the physical features are extracted, auditory *Gestalten* that involve several elements are formed in the auditory sensory memory. Auditory sensory memory is responsible for detecting changes in the auditory environment by predicting future events on the basis of the regularities in the environment. The event related potential (ERP) that reflects the detection of this change was identified by Näätänen and colleagues and is called mismatch negativity (MMN, Näätänen et al., 1978). MMN is a negative potential evoked by an event that, based on regularities constructed in the context it is presented in, does not fit into the pattern. The classical MMN task is an odd-ball paradigm where the infrequent deviant note has a different frequency than the regular note. Studies have demonstrated the effect also with phonemes (e vs *ö*) or more abstract parameters like interval direction (Saarinen et al., 1992).

MMN usually peaks between 150 and 250 ms after stimulus onset, has negative polarity, and is observable at the frontocentral and central electrodes. The peak latency is modified by the size of the change. Large changes, for example, when the frequency difference between standard and deviant note is big, decrease the peak latency while more subtle changes increase the peak latency (Sams et al., 1985; Näätänen et al., 1989, 2007).

MMN is elicited as a response to irregularities in the repetitive auditory environment. If the change occurs in pitch, timbre or other sound features, the evoked potential is called physical feature MMN (phMMN). While the early studies focused on the physical changes in the sounds, later experiments showed a comparable response also to more abstract features like interval direction (Saarinen et al., 1992). The respective component is therefore known as abstract feature MMN (afMMN).

A prerequisite for MMN response is a sufficient amount of repetitive context to build an expectation before the deviant is presented. MMN is not elicited by stimuli in the first positions of the sequence (Cowan et al., 1993) or if the inter-stimulus-interval is longer than 10 seconds (Sams et al., 1993).

Processing of such changes takes place automatically and irrepressibly even outside of the attentional focus. Clinically this effect has applications in diagnosing dyslexia (Kujala and Näätänen, 2001), because in children with specific language problems deviant phonemes may not elicit an MMN; or in predicting whether a person is likely to wake from a coma (Daltrozzo et al., 2007), as patients who show an MMN have significantly better chances for regaining consciousness.

As next, Music-Syntactic Analysis refers to the stage of auditory perception where processing of structural elements such as tones, intervals or chords within their musical context takes place. It relies on the already existing representations of music-syntactic regularities in the long-term memory (Koelsch, 2009). Note, that *musical syntax* is not the equivalent to the linguistic syntax, but referring to the complex regularities music is structured around that are similar to the syntactic structure of language. The corresponding ERP component with latencies around 180-350 ms is in general lateralized to the right (and therefore named early right anterior negativity (ERAN); Koelsch, 2009), although bilateral effects have also been reported (Steinbeis et al., 2006; Loui et al., 2005).

ERAN has been shown to depend on the degree of violation, that is, more pronounced violations of the rules increase the amplitude of the elicited ERAN (Koelsch et al., 2000). For example, very unexpected chords with a larger degree of harmonic distance elicit larger ERAN than less unexpected chords (Steinbeis et al., 2006). ERAN can also be elicited by in-key chords that are music-syntactically irregular (Koelsch and Jentschke, 2008; Koelsch et al., 2007), indicating that the process incorporates various aspects of the musical rules, not only tonal hierarchy.

Processing of musical syntax has also been studied without inducing expectancy violations. Minati et al. (2008) used melodies in comparison to unstructured note sequences which consisted of a randomly chosen periodically repeated fixed note. The results for both musically trained and untrained individuals showed that N2 in response to each note had a longer latency and more frontal distribution if presented in a melody, suggesting that there was expectancy for melodic structure. The latency and topography corresponds to the ERAN even though no expectancy violation was used, suggesting that ERAN is responsible for musical syntax more broadly.

Meaning in the music can be conveyed using various means: common patterns or forms (like heart beat), suggestion of mood (sad), extramusical associations (wedding march), or use of musical structures to create tension. The respective ERP N400, with latency range 300-500 ms, is usually observable in the posterior temporal regions (Koelsch and Siebel, 2005).

Last, the late positive components (P600) are implicated in reflecting the processing of structural integration, analysis and, if necessary, repair in both music and language, supporting the suggestion of largely overlapping neural resources for both (Koelsch and Siebel, 2005).

1.2.2 Musical expectancy

Predictive processing is not something music-specific, but refers to all types of processing which is concerned with the future events in the body or in the environment and is relevant to perception, motor and cognitive control, decision making and other cognitive processes (Bubic et al., 2010). Yet, generation and confirmation or violation of built expectations is considered particularly important for aesthetic experience, meaning, and emotion communication in music (Pearce and Wiggins, 2006; Meyer, 1956).

According to the Implication-Realization theory by Narmour (1991), two simultaneous and partly interconnected input systems – top-down and bottom-up – are responsible for generating expectations. Conflict, mismatch and interruption may occur both inside and between them. The top-down system is concerned with comparing representative schemata and current input, being flexible, variable, and empirically driven. Expectations are influenced by previous knowledge as well as immediate learning during the piece, e.g., repetitive patterns within a melody shape expectations for the next possible occurrence of the same pattern (Rohrmeier and Koelsch, 2012). The bottom-up system is automatic, unconscious and preprogrammed, responsible for processing formal similarities and differences, as well as parameters of the sound like duration, consonance, interval direction, etc. (Narmour, 1991), which determine the degree of closure the sequence carries (Pearce and Wiggins, 2006).

Predictions can be formed if the events they are related to occur in non-random fashion. Either deterministic or probabilistic regularities need to be available to be extracted and used to predict future events. In case of random events or novel situations, existing knowledge can be used to create analogies (Bubic et al., 2010).

In music, predictive processing is fundamental in three ways: it carries the essence of music's temporality, is crucial to musical interaction and synchronization and is linked with specific emotional and aesthetic effects (Rohrmeier and Koelsch, 2012; Meyer, 1956; Sloboda, 1991).

Musical expectancy can be built on either "what" is about to happen and "when" it might happen. The "what"-aspect includes predictions about melody, phrase structure, harmony, perhaps also key and form, and in research into this kind of expectations the listener is assumed to make predictions regarding the next note or phrase boundaries. The expected event is chosen from a set of possible events of the same kind. The "when"-aspect is divided into rhythmic and metric predictions, where metric regularities are likely to create peaks of attention at strong beats and rhythmic patterns learned from the context form predictions for their continuation (Rohrmeier and Koelsch, 2012). Interaction between the "what" and "when" is also possible, for example, if expected note occurs earlier or later than expected and may therefore be regarded as unexpected.

Involvement of several memory systems is presumed in forming musical predictions: auditory sensory memory, which, with a span only in a range of seconds, acts as a buffer and participates in forming local predictions for situations like pitch repetitions and auditory Gestalt formation; working memory's task is storing short-term context for maintaining and updating the current mental model of the musical structure – to predict the end of the phrase, it is necessary to remember how it started; long term memory, additionally retrieves and stores the learned information regarding musical style-specific rules and schemata (Rohrmeier and Koelsch, 2012).

In this thesis, the two first studies focus on the "what" aspect of the musical expectancy, where the predictions for the following note belonging to a certain key are occasionally violated.

1.2.3 Musical training and brain plasticity

Music, and in particular music-making, activates almost all cognitive functions - perception, memory, sensory-motor coordination, planning, emotion, social cognition (Koelsch and Siebel, 2005). Intense practicing of a complex task leaves its marks also on the structure of the brain. While it would be difficult to conduct experiment where the subjects are asked to perform a task for several hours a day for many years, many people have done it voluntarily when learning to play an instrument and can now be studied in order to reveal long term effects of musical training.

Structural changes related to musical training have been identified in several brain areas. Schlaug, Jäncke, Huang, and Steinmetz (1995) showed an increase in the size of the corpus callosum, which was more pronounced in individuals who had started their training before the age of seven. A good interhemispheric communication is necessary for executing complex bimanual tasks like playing a musical instrument, hence the adaptation to the demand of better connectivity has taken place.

Larger primary motor cortex in musicians, particularly on the right side and in correlation with earlier start of the training, has also been reported, probably resulting from the increased exercise with the non-dominant (usually left) hand (Schlaug, 2001). Larger representations for fingers have also been found, with specific differences depending on the instrument – for (right handed) piano players the finger movement representation was larger in the left hemisphere and for violin players in the right hemisphere (Bangert et al., 2006; Wan and Schlaug, 2010).

Larger planum temporale on the left side has been associated with absolute pitch (i.e. the ability to name each note without a reference Loui et al., 2011; Schulze et al., 2009). While it is suggested that there is a strong component of predisposition, musical training starting before the age of 6 years has found to play a significant role. Children who learn music according to the "Suzuki method" (learning music by ear) are more likely to develop absolute pitch than other children (Oechslin et al., 2010). It is currently agreed, that early start of musical training is necessary, but not sufficient for developing absolute pitch. In addition to the planum temporale assymetry, local hyperconnectivity between perception and categorization areas is also been suggested as the underlying structure for absolute pitch (Loui et al., 2011).

Short-term musical training has also been shown to bring about plastic reorganization. In a study with non-musician adults Lappe et al. (2008) demonstrated significant plastic reorganization in auditory cortex after only 200 minutes of training.

Besides of the evidence emerging from the imaging studies and demonstrating structural changes, the effects are evident on the perceptual level, showing that the changes in the structure have behavioural implications. Musically untrained individuals are able to perceive and differentiate musically complex regularities, suggesting that the processes involved are not solely a result of extensive musical training. However, quantitative changes as a result of musical training have been shown. Koelsch, Schmidt and Kansok (2002) compared musicians and musically untrained participants and showed that the ERAN was larger in amplitude in musicians. This possibly reflects availability of more specific representations of music-syntactic regularities resulting from long-term musical training (Koelsch, 2009; Koelsch et al., 2002). Similarly, MMN has been shown to be larger in musically trained individuals (Tervaniemi et al., 2001).

1.3 Music and mood

The terms *emotion* and *mood* are often used interchangeably, but still describe closely related but distinct phenomena. For this thesis, *emotion* describes a short, valenced state, a reaction to a goal-relevant external or internal event, whereas *mood* describes a more enduring and perhaps less intense combination of several emotions (Beedie et al., 2005). Scherer and Zentner (2001) suggested that emotions consist of physiological arousal, expressive behaviour, subjective feeling, action tendency and appraisal that are constantly changing. Panksepp (2003) defines emotion as a phenomenon with motor-expressive, sensory-perceptual, autonomic-hormonal, cognitive-attentional, and affective-feeling components. Both models emphasize the multitude of components involved and complexity of the process.

In this section an overview is given on research into the process and underlying neural correlates of generating and regulating emotions, emotional response to music in healthy individuals as well as in case of depression, and the ways music and its emotion-evoking properties are used in therapy.

1.3.1 Generation and regulation of emotions - models and neural correlates

A simple four-step model of emotion generation contains stimuli in context (thoughts, people, events), followed by attention to the stimulus or a part of it, appraisal (aversive or appetitive, depending on current goals or needs) and response (experience, behaviour, physiological reaction) (Ochsner et al., 2012).

Based on current neuroscience literature, for the time being, distinct neural systems for discrete emotions have not been identified and it can rather be distinguished between positive and negative appraisals, which can be associated with specific neural systems (Ochsner et al., 2012; Kober et al., 2008).

While there are several cortical and sub-cortical systems involved in appraisal and response stages of emotional reaction, there are four main ones most frequently discussed in relation to appraisal and emotion regulation. One region, which is involved in appraising affective goals is amygdala. While it is generally responding to arousing stimuli, it tends to express a bias towards negative stimuli like threats, and evoking responses like fear. The second, ventral striatum, plays a role in learning which cues (expressions, behaviours, etc.) predict positive outcomes. The task of the third region, ventromedial prefrontal cortex, is to integrate the evaluations made by the two previous regions with input from other regions as well, which may add information regarding previous similar events (medial temporal lobe) and current goals (prefrontal cortex) (Price, 1999; Ochsner et al., 2012). The insula, as the fourth system, has been among other tasks implicated in negative affective experience and its anterior regions are believed to play a role in processing disgust, but as new findings suggest it is involved in awareness and introspection, it may also potentially carry neural correlate of consciousness. Anterior insular cortex has been found to activate for stimuli like thirst, sensual touch, itch, coolness, distension of the bladder, dyspnea (Craig, 2009).

Emotion regulation is a process by which a person can influence the type, time, expression and experience of an emotion they have. It is guided by either explicit or implicit regulatory goals and is therefore an active process, which either modifies the ongoing emotional response or initiates a new one and can impact the emotion generating process in different points (Gross, 1998). The explicit strategies to regulate emotions can be divided into five categories. First, it is possible to select the situations one is exposed to and therefore avoid situations where unwanted emotions may be elicited. Second, one can modify the situation which elicits an unwanted emotion with changing the environment, leaving the room, for example. The third strategy involves selecting the stimuli one attends to and is called attention deployment, divided to selective attention and distraction. With shifting the attention to either internal or external stimuli in order to modify the ongoing emotion process. Cognitive change (reappraisal) as the fourth strategy involves changing the meaning of a stimulus, reinterpreting it in a more suitable way. The last, response modulation strategy interferes with the emotion generation process at the expression stage, enabling to choose a reaction one prefers. The most common reaction is not to react – suppress the response to not reveal one's actual emotion (Ochsner et al., 2012). Of these strategies, only reappraisal may have the effect of changing the emotional response to the stimulus more permanently and thanks to this feature, this strategy plays an important role in cognitively informed therapies and particularly in work with negative automatic thoughts, which can be changed in order to modify the initially negative emotional reactions.

Cognitive emotion regulation is largely based on reappraisal and three neural systems contribute to its generation and application. Reappraisal of negative emotions has been found to activate dorsal anterior cingulate cortex, which is implicated in performance monitoring, dorsolateral and posterior parts of prefrontal cortex, which, together with inferior parietal regions direct attention to the features of the stimulus that need a change of interpretation or meaning. As third, the ventrolateral prefrontal cortex, implicated in selecting goal-appropriate responses, may be used to choose a new, more appropriate reappraisal. All previously described regions involved in emotion generation are modulated by the reappraisal system (Ochsner and Gross, 2005; Ochsner et al., 2012).

Brain areas engaged in processing emotions in general are also involved in processing music-related emotions. Passive music listening has been found to activate several limbic and paralimbic areas. In response to pleasant music increased activation in the ventral striatum (including Nucleus Accumbens (NAcc)), hippocampus, and anterior insula, and decreased activation in amygdala has been shown (Blood and Zatorre, 2001; Koelsch et al., 2006b; Brown et al., 2004). NAcc is activated in response to strong motivational stimuli, like chocolate and drugs of abuse and the similar response evoked by music indicates its comparable power as a stimulus. Chills, being intensely pleasurable, have been shown to activate ventral striatum, midbrain, amygdala, orbitofrontal cortex, and ventral medial prefrontal cortex - regions involved in reward, emotion, and arousal (Blood and Zatorre, 2001; Menon and Levitin, 2005; Brown et al., 2004). Amygdala activation has also been reported in response to scary music (Gosselin et al., 2005, 2007), similarly to other fear-inducing stimuli. A lesion study has shown a dissociation between lesions in ventromedial prefrontal cortex and right somatosensory cortex – patients with the former lesion showed impaired in skin-conductance response to music, but could adequately evaluate their subjective feeling, while patients with the latter lesion showed reversed responses (Johnsen et al., 2009).

1.3.2 Emotional response to music

While it is generally agreed that music can evoke emotions, the underlying mechanisms have received little attention from the researchers, perhaps because of the complexity that emotional reactions comprise of. As Panksepp and Bernatzky (2002) stated: *"... this medium is so complex that for a long time methodologically rigorous psychologists despaired of ever distinguishing to what extent emotional changes were due to specific music attributes such as rhythm and melody, as compared to personal memories and acquired dimensions of cultural significance."* (p. 134).

It is important to differentiate perception of emotion and feeling an emotion – a notion which feeds the ongoing debate on whether the emotions evoked by music are real. On one side of the debate Emotivists argue that music can elicit real emotional reactions while on the opposing side Cognitivists claim that music only expresses emotions (Scherer and Zentner, 2001) and the listeners are able to recognize the emotions music expresses without really experiencing them. According to the Cognitivists, music does not evoke genuine emotions because there is no evolutionary function of the 'musical emotions'. Juslin and Laukka (2004) emphasize the importance of differentiation between perception and induction for three reasons - the underlying mechanisms may differ; induced emotions are more difficult to measure and need adaptation of methods; perceived and expressed emotions may differ from the felt emotions.

Emotivists' views concur with the results of several imaging studies, which, as described above, have demonstrated overlap between regions activated by musical and non-musical emotions and there is no experimental evidence that would differentiate musical and non-musical emotions on neuronal level (Juslin and Västfjäll, 2008). Additionally, if it is assumed, that the function of music is to express and communicate emotions, as Emotivists claim (Juslin and Västfjäll, 2008; Meyer, 1956), it seems to add the allegedly "missing" evolutionary function or goal for Cognitivists, as having a mean to reliably communicate basic emotions seems rather important (Juslin, 1997; Resnicow et al., 2004) and the "additional feature" of empathy aids in understanding the other person's point of view. Another point the search for "goal" for emotions seems to overlook is that in daily life the experience of emotion may become a goal by itself, as can be concluded from the responses for use of music, where the majority of participants used music to manipulate their current emotions in a certain direction (Juslin and Laukka, 2004) – one may play with a cat because it brings joy or go sky diving for the excitement (are they therefore less real?) and listen to sad music when they want to be sad – music seems to be a really cost-effective way to get the wanted emotion, which, if we are to assume that having the emotion can be the goal of the process, would count as "real" emotion and the search for "more subtle, music specific emotion", as worded by Scherer and Zentner (2001), could end.

Moreover, Emotivists' views are supported by several studies which have demonstrated how music evokes various components of emotional reactions: Subjective feeling (Juslin and Laukka, 2004), psychophysiological response (Krumhansl, 1997; Steinbeis et al., 2006), brain activation (Blood and Zatorre, 2001; Koelsch et al., 2006b), emotional expression (Lundqvist et al., 2009), and emotional regulation (Chamorro-Premuzic et al., 2009).

Most studies in the field focus on a single aspect of emotional reaction, which most commonly is subjective feeling or psychophysiological arousal. The advantage of concentrating on one aspect at a time is that it enables accumulation of knowledge on separate aspect before the complexity of the whole emotional reaction is tackled.

Naturally, acknowledging the concerns of the Cognitivists, a distinction must also be made between the emotion expressed by the music (or the performer) and what is experienced by the listener. Many previous studies failed to state explicitly which of the both was measured, making interpretation of the results difficult (Konečni, 2008). In the studies presented in this thesis this concern was addressed by explicitly distinguishing between the emotions the participants felt and how much they liked the stimulus music.

Which emotions the music was meant to express was not addressed as the musical pieces had been used in a previous study where the expressed emotions had been investigated (Koelsch et al., 2010).

Konečni (2008) is critical towards genuineness of musical emotions also from the perspective that the emotional response evoked does not always correspond to the emotion expressed – emotion A in music does not necessarily and always induce emotion A in the listener. Research shows, that this, indeed is the case as individuals report feeling strong emotions while listening to music in average 55% of the time and the experience depends on the environment, state of mind and kind of music in relation to preference. While asked directly, whether they experience the emotion the music is expressing, over 70% answer "Always" or "Often" (Juslin and Laukka, 2004). It remains unclear why, according to Konečni, the music – emotion connection needs to resemble conditioning for the emotion to be "real", as the responses to non-musical real life stimuli may also vary depending on various factors like previous experience or meaning given to the stimulus. As people actively use music for emotion modulation purposes – 50% of participants reported using music to change mood, 80% to vent emotions through listening to music (Juslin and Laukka, 2004), it would seem a strange thing to do if music actually can not induce emotions and would leave futile all efforts made by advertisers and film industry to actively change the emotions of the listeners.

Regarding induction of powerful basic emotions, according to the listeners' reports, most frequently felt emotions were "happy", "relaxed", "calm", "moved", "nostalgic", "pleasurable", "loving", "sad", "longing", and "tender" (Juslin and Laukka, 2004). The 10 most frequent feelings therefore contain both basic and more complex emotions.

Konečni is probably one of the more radical Cognitivists and it becomes more apparent when looking into his definition of emotion: *"... emotions can be treated as dynamic episodes with feedback loop features and interacting cognitive, physiological, facial, and motor components. They typically have unambiguous mental and physical cause and object and they guide and energize behavior in situations with serious biological consequences – thus becoming memorable events in human phenomenology."* (p.116-117). He also claims that emotions are experienced rarely, because of the high cost. It implies, that only very powerful and overwhelming emotional states could be called emotion and everything less extreme (or a mixture) should be called mood - which, according to his view is not put together from different emotions. Therefore, it seems that one of the main reason for contrasting views here is the significantly different meaning of the main terms. If one is to believe, that emotion is something rare and extremely intense with high physiological and psychological cost, then it may become apparent, why by this definition the emotion evoked by music lack the exhaustive effect and could be considered not intense enough to qualify as emotion.

One of the emotional and physiological phenomena related to music, that might by the criterion of intensity count as emotion also by Konečni's definition is called "chills" of "shivers down the spine", which is a powerful experience accompanying the pleasure of music and activates brain areas related to reward and motivation (Blood and Zatorre, 2001). From another perspective – the above mentioned "chills" have been found to be related to use of unexpected irregular notes or chords in music, which indicates that specific features of music can evoke specific emotional reactions. A similar connection exists between tears and melodic appogiaturas, to mention a few (Sloboda, 1991).

As described above, there has been a debate on whether or not music evokes "real" emotions and research has shown which areas in the brain activate in result of these "real or not real" emotions, yet little attention has been paid to how these emotions are evoked (Juslin and Västfjäll, 2008).

The default mechanism of how music evokes emotions is suggested to be cognitive appraisal, but this mechanism alone does not seem to be sufficient to explain all aspects of the experience. To encourage research into the mechanisms underlying the effect music has on people Juslin and Västfjäll (2008) proposed a 6-component model for how music listening can evoke emotions: (1) brain stem reflexes, (2) evaluative conditioning, (3) emotional contagion, (4) visual imagery, (5) episodic memory, and (6) musical expectancy.

Brain stem reflexes are involved in evoking emotions in cases where the acoustic features of the music signal a potentially important event, resembling a sound that outside music could signal danger or sudden changes in the environment. Fast, loud, noisy sounds rapidly increase activation of the central nervous system using the ability of the reticular system to increase arousal to attend to potentially important stimuli in the very early stages of auditory processing.

Evaluative conditioning (also called affective learning or emotional conditioning) refers to a process where a specific piece of music, after a repeated occurrence together with another positive or negative stimulus, evokes the emotion even without the stimulus.

Visual imagery is the mechanism used in music to create a perception of scenery. Listening to "The Blue Danube" lets one imagine a beautifully flowing river or "Pictures at the exhibition" various art works. Besides this more pictorial imagery a more general idea of movement or space in the music has been suggested. It is suggested, that the experienced emotions using imagery are likely to be a result of interacting structures of both music and imagery. Music induced imagery has also been used to facilitate relaxation and guided imagery is frequently used in music therapy (Juslin and Laukka, 2004).

Episodic memory is involved in music-induced emotions when a piece of music evokes a memory of an emotionally important event and alongside also the emotions related to the event. It has been shown, that music is specifically used for the purpose of remembering an emotionally significant event (Sloboda and O'Neill, 2001) and nostalgia is one of the most frequently reported feeling during music listening (Juslin and Laukka, 2004).

Musical expectancy is a mechanism based on the ability of humans to predict the next probable musical event. Emotions are evoked if the predictions are confirmed or violated, yet, to have an aesthetic meaning, the tension created by the expectancy violation must be relieved by a satisfying resolution (Meyer, 1956). The rules for how music is constructed are learned in the childhood by exposure (Trainor and Trehub, 1994) and thereafter used automatically. However, the learned rules apply to only some levels of expectancy and many different expectations may be created also varying between individuals (Juslin and Laukka, 2004).

Emotional contagion relies on the ability of the listener to recognize the emotions the music is expressing and experience the same emotions, perhaps through empathy or involvement of mirror neurons. Studies using electromyography have shown in response to "happy" music an increased tendency towards a facial expression resembling smile, whereas "sad" music evoked an expression resembling frowning (Lundqvist et al., 2000). Music listening appears to activate neural circuits involved in premotor representations of vocal sound production and it could therefore be reflecting internally expressed emotions induced by the music (Koelsch et al., 2006a). It is also suggested that emotions are picked up from the music the same way as from language based on specific sound features that both of them share. This theory still needs further investigation, however, the overlapping neural basis for music and language supports this explanation (Juslin and Västfjäll, 2008).

In this thesis the focus is on the two last described mechanisms proposed by Juslin and Västfjäll (2008) – emotional contagion and musical expectancy. In the music-making and listening studies we concentrate on emotional change brought about by exposure to cheerful music and factors that could modulate this change, like personality, musical preference and general emotional state (depressed or normal). In the perception studies the focus is on one type of musical expectancy violation - out-of-key notes and mechanisms for how this type of violation is detected by either musically trained or not trained individuals.

These two mechanisms were chosen for their predominantly situational musical nature without a large component of, as Panksepp and Bernatzky (2002) word it, *"personal memories and acquired dimensions of cultural significance."* (p.134). Brain stem reflexes are, indeed, reflexes and have less to do with music and more with the need to attend to potentially important events in the environment. Evaluative conditioning and episodic memory have significant memory or cultural component, and visual imagery combines musical and visual modalities. With expectancy violations and emotional contagion the experience and emotion are more likely to occur "here and now" and can hence potentially be measured more reliably, even though memory component can not be completely excluded from the music-making context. Nevertheless, even there, the music the participants created was completely new, despite some of them being familiar with some of the underlying pre-recorded pieces.

1.3.3 Depression and the emotional effects of music

Depression is an affective disorder characterized by low mood, reduced energy and decreased activity along with increased fatigue and reduced interests, concentration and enjoyment of activities previously liked. Sleep, appetite and libido may be affected as well. Low mood is relatively stable, possibly accompanied by psychomotor retardation, agitation, apathy, feelings of guilt and worthlessness (ICD-10, 2011). ICD-10 distinguishes three categories of depression based on the number and severity of symptoms - mild (two-three symptoms, patient is able to carry on their daily activities), moderate (four or more symptoms, difficulties with continuing ordinary activities), and severe (several symptoms in distressing degree, suicidal thoughts may be present, usually unable to complete their daily tasks).

Depression is one of the major health problems faced by the society. It is the leading cause of disability, affecting 121 million people worldwide, while suicides cost 850 000 lives every year. The prevalence is rising and It is predicted that by year 2020 depression will rank 2^{nd} among contributors to the global burden of disease (WHO, 2010). An average depressive episode lasts 3 to 4 months. Circa 50% of the patients diagnosed with their first depressive episode do not experience a recurrent episode while a large proportion may occasionally relapse with complete remission between the episodes, and for circa 20% the disorder takes a chronic course lasting 2 years or longer (Eaton et al., 2008; Spijker et al., 2002).

Chronic depression accounts for approximately 47% of patients treated in psychiatric out-patient facilities (Torpey and Klein, 2008) and is divided into four sub-types by course of the disorder – dysthymia, which is characterized by mild and persistent dysphoria and other depressive symptoms, which do not reach the severity of full depressive disorder; chronic major depression; recurrent major depression with incomplete remission between episodes; and double depression, where major depression episode is superimposed to already existing dysthymia (von Wolff et al., 2012; Torpey and Klein, 2008). Individuals with incomplete remission may function fairly well between the episodes and consider themselves to be in remission despite some of the symptoms still being present, just to a lesser degree, however, it has also been shown, that patients who score under the cut-off on the Hamilton Depression Rating Scale, may consider themselves not to be in remission, if they experienced functional impairment or perceived significant decrease in the quality of life due to the symptoms (Zimmerman et al., 2012).

Various treatments are available including medication and psychotherapies but fewer than 25% of the affected individuals have access to these therapies (Kessler et al., 2003; WHO, 2010). Psychotherapy is expensive and limited in availability leaving people to wait for lengthy periods of time before they can be treated. Also, recent meta-analyses have shown, that the benefits of both psychotherapy (Cuijpers et al., 2010) and antidepressants (Kirsch et al., 2008) have been overestimated and the combination of both in treatment of various sub-types of chronic depression shows small, but statistically not-significant effect on depression treatment outcomes compared to both treatments separately, even though the effect of combined pharmaco- and psychotherapy on quality of life was small, yet significant (von Wolff et al., 2012). However, in the latter meta-analysis only 8 studies were included and the effect was largely dependent on the target disorder, where studies with chronic major depression showed greater effects than studies with dysthymic patients and types of both psychotherapy and medication showed differential effects. In contrast, the STAR*D study (Gaynes et al., 2008), showed that adding a new drug vs adding cognitive therapy did not change the outcome, even though the effect was slower with cognitive therapy. In the same study, while only 33% of patients reached remission after the first course of antidepressant treatment, after up to three additional treatment courses with combination of either additional drugs or psychotherapy, 67% reached remission, leaving over 30% still symptomatic.

Hence, the search for cure continues and because of the adverse side effects of antidepressants and high costs of both psychotherapy and psychopharmaca, research has branched from the yet better drugs path also in the direction of interventions from mind-body framework and creative therapies, including music-therapy (Erkkilä et al., 2011) and mindfulness based approaches (Kenny and Williams, 2007).

Pathophysiology of depression

Depression is a complex disorder and various explanations for the behavioural and affective symptoms have been proposed. Some of the theories are based on the observed effects of medication (e.g. the monoamine hypothesis), others on behavioural and physiological observations (e.g. the sickness behaviour theory).

The early Monoamine theory suggested that the main mechanism of action of monoamine inhibitor type of antidepressants is the downregulation of post-synaptic noradrenalin and serotonin receptors which would then cause elevation of the previously low mood. However, antidepressants do not elevate mood in healthy individuals, and psychostimulants, which do elevate mood in healthy individuals, do not seem to work as antidepressants (Harmer et al., 2009). Moreover, more selective monoamine inhibitors do not necessarily show better outcomes in reducing depression, leaving it unlikely that the dysregulation of serotonin and noradrenalin alone is solely responsible for the depressive symptoms (Harro and Oreland, 1996).

Alternatively, Harmer and colleagues (2009) proposed that antidepressants work through decreasing the negative affective biases, thus allowing an increase in positive stimulation and promoting a gradual mood improvement. This supports the idea that antidepressants and psychotherapies together would be more effective than each of them on its own - medication decreases the negative bias which allows the patient to benefit from the psychotherapy and make the changes in thought patterns and environment that would facilitate the improvement.

The Sickness Behaviour hypothesis emerged from the observations that the symptoms characteristic to infections – fatigue, sleep and appetite disturbances, difficulties in concentrating and various somatic symptoms – are similar to the symptoms of major depression, suggesting a link between depression and immune system activation. Evidence for this association comes from a number of studies that show higher than expected prevalence of depression in patients with autoimmune disorders getting treatments with immunosuppressive agents like interferon-α or IL-2 (Wager-Smith and Markou, 2011). Changes in the blood levels of pro-inflammaory cytokines are also reported in depression patients (O'Brien et al., 2004; Hestad et al., 2009). Moreover, anti-inflammatory medication as simple as acetylsalicylic acid can have an antidepressant effect or the ability to accelerate the onset of the effect of antidepressants (Mendlewicz et al., 2006).

Even though the short term outcome of depression treatments is often quite good, long-term prospects show recurrent episodes for a large proportion of patients (Eaton et al., 2008; Spijker et al., 2002). Several factors predicting relapse have been identified including severity of first episode, delayed start of treatment, and recurrent episodes in the past. With the increase of the number of past episodes the remission interval grows shorter, responsivity to antidepressants and quality of life decrease, and the patient faces long-term disability (Harro and Oreland, 1996). This suggests that there are likely to be persistent changes in the brain which aggravate over time if depression is left untreated. Indeed, decrease of hippocampal volume has been documented in depression (Campbell et al., 2004), which becomes increasingly visible in cases with at least two episodes or duration of two years (McKinnon et al., 2009). Moreover, reduced prefrontal activity along with increased activation of limbic areas have been reported in depressed patients (Siegle et al., 2007), accounting for cognitive difficulties related to depression as well as dominance of negative emotions. While depression is considered to be predominantly affective disorder, cognitive deficits related to major depressive disorders are found to be consistent, replicable, and clinically significant. Corresponding the most affected brain areas, the deficits predominantly emerge in executive functions, working memory, attention, sensory-motor and processing speed (McIntyre et al., 2013). The presence and degree of cognitive deficit largely determines the functional outcome and further quality of life of the affected individual (Buist-Bouwman et al., 2008).

Involvement of neurogenesis or more specifically suppression of neurogenesis has been suggested in studies where antidepressant treatment has been shown to reverse the depression-related atrophy in hippocampus along with the decrease of behavioural symptoms of depression - which the antidepressants fail to elicit when the neurogenesis is blocked by medication or gene manipulations in animal models (Wager-Smith and Markou, 2011).

Another major factor potentially contributing to the development of a depressive disorder is stress. Primary depressive episodes are in 70-80% of cases preceded by a stressful life event (Kendler et al., 1999) and individuals suffering from Major Depressive Disorder (MDD) have been found to have elevated basal cortisol levels and blunted response to stressors (Burke et al., 2005).

Based on the findings described above Wager-Smith and Markou (2011) have proposed a new theory for the process of coping with stress, which, as a dysfunctional outcome results in depression. They emphasize the existence of a positive outcome of the stress cycle - stressful events are experienced by every individual and in most cases people cope with the event, learn from it, and do not get depressed.

According to Wager-Smith and Markou (2011), in the healthy stress response cycle stress creates a microdamage in the brain. A recovery process is initiated, similarly to wound healing. Pro-inflammatory cytokines are released to dispose of the cellular debris. Increase of neuroinflammatory activity manifests in sickness behaviour and psychological pain. When the demolition phase has finished, neuroinflammatory activation decreases giving way to release of neurotrophines that increase neuronal growth. As a result, the microdamage is repaired, the symptoms resolve, and the brain structure has changed. The function of this neuronal remodeling is possibly adaptation to the stressor that may lead to better coping the next time a stressful situation is encountered.

However, if the original microdamage is not repaired properly and the inflammation reaction does not cease, continuous inflammation induces additional tissue destruction that results in persistence of psychological pain and other symptoms that manifest in chronic depression (Wager-Smith and Markou, 2011).

Cognitive models of depression

Besides the somatic symptoms characterizing depressive disorder, a number of cognitive distortions are present that are not explained on the physiological level, but contribute to the suffering related to depressive disorder. To account for these symptoms and in particular, to have an explanation for the disorder at times when the physiological correlates were not yet known, cognitive models of depression were developed. They are widely used in psychotherapeutic work to conceptualize the problem, modify the dysfunctional cognitive patterns and also to explain the patients how depression develops and how it is sustained. Research shows, that understanding the nature of the disorder and learning to challenge the negative thoughts strongly contributes to the remission (Beck, 2008).

The most well-known depression model was proposed by Beck (1976), known as the *negative cognitive triad*, involving pessimistic orientation towards the future (hopelessness), negative views of self and negative views of the world. The negative thinking patterns are present in three levels: negative automatic thoughts, evaluation biases, and beliefs. The causes of events perceived as negative are by the patient believed to be stable (not going to change), global (in all situations) and internal (caused by the person). This predisposition leads to a situation where an individual, when confronted with a stressful situation, interprets the events more negatively based on the negative perception they have of themselves and the world and is therefore likely to become depressed (Beck, 1991). The symptoms are thereafter also interpreted in light of the negative bias, continuing the loop, supported by automatic thoughts like "i can not get anything done, because i'm a lazy failure." (Beck, 2008).

The expanded cognitive model, also developed by Beck (Beck, 1996), joins the components of the previous model to a concept of *mode* – "a network of cognitive, affective, motivational, behavioural, and physiological schemas" (Beck, 2008, p.971), which, once activated is relatively autonomous and not influenced by positive events, that is, positive experiences do not reverse the negative interpretation of the situation. The maladaptive negative cognitive schemas activate rapidly, involuntarily and require little resources, which, without therapeutic intervention, allows it to overrule the adaptive cognitive control system (executive functions, reappraisal, and problem solving), that would challenge the negative bias, but requires deliberate effort (Beck, 2008).

Additional factors contributing to the cognitive vulnerability to depression include low self-esteem (Beck, 1976), adverse early life events (Beck, 2008), which increase sensitivity to stressful events potentially triggering depression later in life (Burke et al., 2005; Kendler et al., 1999), and dysfunctional beliefs characteristic to personality disorders (35% - 65% of people diagnosed with major depressive disorder have personality disorder, Craighead et al., 2011).

Stress seems to be the crossing point for the cognitive and physiological models, leading from the negative evaluation of the situation to triggering the physiological reactions described in the model by Wager-Smith and Markou (2011). Increased activation of the limbic system and decreased activation of prefrontal areas observed in depression patients (Siegle et al., 2007) could explain negative emotional reactions' dominance over more objective and adaptive reactions.

Measuring depression

Even though various physiological markers of depression exist (Hestad et al., 2009; Burke et al., 2005), diagnostics is currently still conducted based on verbal and visual data acquired through clinical interviews and questionnaires. Some of the measures are specific to depression, like the Hamilton Rating Scale for Depression (HAMD, a semi-structured interview, Hamilton, 1967) or the Beck Depression Inventory (BDI, self-administered questionnaire, Beck et al., 1961). Other measures cover a wider range of disorders to account for comorbidity, as additional disorders from the neurotic and stress related range (F40-F48 in the ICD-10) are common. For example, Emotional State Questionnaire (EST-Q2) screens for Depression and Anxiety, with sub-scales also for Agoraphobia-Panic, Fatigue, and Insomnia (Ööpik et al., 2006) and thus can have an advantage over the Patient Health Questionnaire (PHQ-9, Kroenke et al., 2001) commonly used in the UK. However, as PHQ-9 is the screening tool of choice in the NHS, we used PHQ-9 in the UK sample.

Although questionnaires could be considered more "objective" as the data are provided by the patient without interference by attitudes or interpretations of the clinician, points are counted and compared to category cut-offs, diagnosis is never based on a questionnaire result alone. Patients' own accounts on their condition are affected by their condition and therefore the severity of symptoms is likely to be over- or underestimated.

Interviews conducted by a trained clinician have the advantage of experience and use of visible information besides the verbal – it is possible to evaluate whether a patient looks as fidgety as they report or whether a guilt they express would be comparable with the guilt experienced by a healthy person in the same situation. For example, if a depressed patient has caused an injury to a friend through carelessness, feeling guilty is not necessarily a symptom of depression – a healthy person would experience similar feelings in that situation.

Depression related changes in music appreciation

Depression is characterized by decreased enjoyment of previously pleasurable stimuli, which can involve musical activities the patients used to enjoy before the onset of depression. Some changes in musical preferences and emotion perception in music have been identified.

Depressed patients have a negative bias towards emotional stimuli, which may affect their ability to appreciate and enjoy music. Besides rating positive and neutral stimuli as more negative, in comparison to the ratings of healthy individuals, the patients were also found to report increased intensity to sadness and fear in music but lower intensity to peaceful music excerpts, suggesting that negative information was perceived more intensely (Naranjo et al., 2011).

In a recent study on music preferences in depression Punkanen, Eerola, and Erkkilä (2011) demonstrated that patients suffering from depression disliked angry or highly energetic music. This notion is particularly relevant in the context of music therapy – it would be tempting to choose energetic happy tunes in hope that they will elevate the low mood of the patient. However, if the discrepancy between the emotional state of the listener and the emotions expressed by the music is substantial and the listener therefore strongly dislikes the music, an improvement of the depressed condition can hardly be expected. Hence personal preferences are an important aspect to consider and starting with something less intense could turn out to be more beneficial. We addressed this concern by acquiring preference ratings from the patients for the musical pieces we used and adjusting the musical content of the sessions according to these ratings.

1.3.4 Application of music in therapy

"And so today, like every other day in recent memory
the cellist sits beside the window of his second-floor apartment
and plays until he feels his hope return." (Galloway, 2009, p. 2).

Music therapy is a form of psychotherapy where musical interaction between the therapist and a patient or a group of patients is used to improve, restore or maintain health (Bruscia, 1991). Scientific evidence for the efficacy of music therapy has started mounting only recently even though it has a long history of being used in a wide range of settings and patient groups.

Music therapy can be divided into passive and active, depending on the level of engagement expected from the patient (Bruscia, 1998). Passive music therapy involves methods such as listening to music, visual imagery to music, vibro-acoustic methods, and requires relatively little effort from the patient, therefore being more suitable for patients with considerable limitations. It is predominantly used for stress reduction, pain relief or energizing (Maratos et al., 2009). Active music therapy involves music-making in various forms (free or structured improvisation, pre-composed, singing, songwriting) which sets significantly higher demands to the patient, but offers potentially more benefits. Active music therapy is often psycho-analytically informed (e.g. Erkkilä et al., 2011), with a few exceptions where the theoretical background is cognitive, and used to give the patient an opportunity to experience themselves in a new way and gain insight into their emotions and relations (Maratos et al., 2009). An important part of this paradigm is discussions and reflections on the music played.

Another distinction can be made between classical music therapy, that concentrates more on emotions and communication (Erkkilä et al., 2011), and neurologic music therapy (Thaut, 2010; de l'Etolie, 2010), which is predominantly concerned with rehabilitation of cognitive functions that have been damaged by an accident or a disease.

Classical music therapy

The emphasis of classical music therapy is on the therapeutic relationship and music is used as a tool for better understanding of the emotions and facilitating communication for people who otherwise would have difficulties expressing themselves (Maratos et al., 2009). The frequency and duration of music-therapeutic intervention may vary in large ranges – from one to six sessions per week for one to six months period. It is estimated that a patient receives a median of 73% of the sessions offered, showing a rather good compliance. Group or individual sessions, or a mixture of both, are used and a variety of methods are applied through the course involving instrumental improvisations, singing, songwriting etc. (Gold et al., 2009). Patient groups vary from children with emotional or developmental problems to adults with a range of psychiatric disorders. In remaining of this section, research on classical music therapy applied to depression is reviewed.

The ability of music to evoke emotions has motivated the use of music therapy with people suffering from affective disorders and emotional problems. The evidence available suggests a beneficial effect if music therapy is added to the standard care (Erkkilä et al., 2011; Gold et al., 2009; Maratos et al., 2009) and a clear dose-effect relationship was found by Gold and colleagues (2009), predicting a small effect on depression symptoms 4 sessions, a medium effect could be expected after 10 sessions and a large effect after 16 sessions (Gold et al., 2009).

However, the evidence base for its efficacy is rather thin with few high quality studies available. Only 5 studies were included in the analysis by Maratos et al. (2009), four of which reported clinically positive effects. Common problems with music therapy studies are heterogenous patient groups and a variety of music therapy methods used that decrease the comparability, along with uncontrolled designs, which led to exclusion of a number of studies (Maratos et al., 2009; Gold et al., 2009). A meta-analysis on music listening reports a tendency for reduction of depression symptoms, but also points out the small number of comparable studies (Chan et al., 2011).

In a more recent randomized controlled trial on music therapy, Erkkilä et al. (2011) reported high attendance rate (18 sessions out of 20), showing very good compliance and engagement, and significantly larger decrease in depression after 3 months in the music therapy group in comparison to standard care, supporting previous findings that music therapy is beneficial for individuals suffering from depression.

Previous research has compared music therapy in addition to the standard care to treatment as usual (TAU) or music therapy and standard care to cognitive-behavioural

(CBT) or other therapy and standard care (Maratos et al., 2009), the effect in such a comparison is not necessarily specific to music, but could perhaps be explained by an additional pleasant activity to the daily routine of the patient. Therefore, to investigate the existence of a music-specific effect, we compared two similar interventions, one of which involved music-making and the other one did not, in a form where verbal reflections on the experience were not used and the role of the patient-therapist relationship was minimal. Arguably, such interventions would not fit under the term "music therapy", but should be called "music medicine" instead (Bruscia, 1998). Nevertheless, as social and improvisational aspects are involved in the musical experience in the group, our intervention is closer to music therapy than to "music medicine", an example for which would be listening to a relaxation CD alone at home.

Low self-esteem and feelings of worthlessness might be the cognitive aspects music-making in a group could positively influence, by helping to reverse the negative self-schema, giving the individuals the opportunity to engage in an activity that gives a feeling of accomplishment, acceptance and belonging. The perfectionism and low self-esteem could, however, may become counterproductive, which is the point where there might be a need for additional encouragement from the therapist.

Music-making as a complex task involving activation of many brain areas and cognitive functions could, in case of depression, contribute to reversing the cognitive symptoms, which play a significant role in functional outcome and quality of life (McIntyre et al., 2013; Buist-Bouwman et al., 2008), also through increasing activation in prefrontal areas where impaired activation has been reported (Siegle et al., 2007) along with evoking more positive emotions, which may therefore weaken the dominance of negative schemas.

Neurologic music therapy

The term neurologic music therapy refers to musical methods used in rehabilitation of neurological problems. The focus is on lesions in the central nervous system and the range of disorders the methods are applied to involves e.g. aphasia, neglect, paralyses and various motor problems (e.g. Thaut, 2010; Thaut and Abiru, 2010; de l'Etolie, 2010).

In contrast to classical music therapy, neurologic music therapy stands on a significantly stronger evidence base (Altenmüller et al., 2009; de l'Etolie, 2010). Methods used here were developed based on the previous knowledge of how music impacts brain plasticity. An advantage of music based rehabilitation programs, in comparison to, for example, physiotherapy, is the experience of pleasure related to music resulting from the activation in the limbic system, contributing to a higher compliance and motivation to continue the intervention (Wan and Schlaug, 2010).

During recent years several novel methods for neuropsychological rehabilitation have been developed, among others Melodic Intonation Therapy (MIT) for non-fluent aphasia (Schlaug et al., 2008; Norton et al., 2009), Rhythmic Auditory Stimulation (RAS) to improve gait (Thaut and Abiru, 2010), Musical Neglect Training (de l'Etolie, 2010), Music-supported therapy for stroke induced motor dysfunction (Altenmüller et al., 2009) and Auditory Motor Mapping Training (AMMMT) to facilitate speech acquisition in autistic children (Wan and Schlaug, 2010).

1.4 Music and personality

Personality is contemporarily defined as a relatively stable set of traits, characteristic to the specific individual and having an impact on how the person relates to the world and other people around them. There is a finite collection of largely-independent traits, that fall in a small number of factors (Digman, 1990). The most common, five-factor model consists of the following dimensions: Extraversion – Introversion, which refers to the needed amount of external stimulation and engagement with the external world; Neuroticism – Emotional stability, which describes the degree of emotional reactivity and proneness to negative emotions (Eysenck, 1970); Agreeableness, describing the degree of concern about social harmony and cooperation; Conscientiousness, which involves self-control, goal-orientedness, and self-efficacy; and Openness to Experience, which includes traits like creativity, curiosity, openness to new ideas, flexibility, adventurousness and liberalism (Digman, 1990). Personality, as a source of individual differences and playing an important role in the interactions between the person and the environment, is therefore likely to affect also the ways a person interacts with the musical part of the environment.

While music preferences in connection to personality differences have received relatively more attention from researchers, differences in mood induction have attracted rather little interest and therefore only a few studies can be reviewed. This section gives an overview of literature on the relations between personality differences and music from both preference and mood induction perspective.

The present thesis aims to contribute to this line of research by further examining associations between personality and music-evoked mood changes. The findings contribute to the evidence that could help taylor music-therapeutic interventions for different patients. In contrast to previous studies we used music-making instead of listening, which could potentially bring about larger changes in mood, related to increased level of activity.

1.4.1 Personality and music preferences

It would be simplistic to claim that people with one kind of personality like one type of music. Even liking in this context is not unambiguous. Preference could refer to musical style, the type of emotion the music expresses or the situations music is preferably experienced.

Some associations between personality traits and preferred music styles have been observed – liking of jazz, classical or folk music are positively related to Openness to Experience while preference for country or pop music was negatively related to Openness to Experience but positively related to Extraversion, Agreeableness and Conscientiousness (Rentfrow and Gosling, 2003).

From the perspective of expressed emotion, energetic and rhythmic music was preferred by energetic and extraverted people (Delsing et al., 2008). Individuals scoring high on Openness to Experience scale were found to prefer a larger variety of musical styles (Rawlings and Ciancarelli, 1997) and their preference for fearful and sad sounding music, as reported by Vuoskoski and Eerola (2011), could relate to their preference for variety. In the same study, happy music was liked by extraverted and agreeable individuals and agreeable individuals tended to dislike angry and fearful music.

By preferred purpose the music serves, personality differences also exist. Extraverted people may prefer to use music on the background of monotonous activities, such as cleaning, perhaps to increase the level of arousal, and might prefer to have music on the background also for cognitive tasks, such as studying. In introverts, background music has been found to interfere with performance in cognitive tasks, hence they might not prefer to use music to accompany cognitively demanding activities (Furnham and Bradley, 1997; Furnham and Strbac, 2002; Cassidy and Macdonald, 2007).

1.4.2 Personality and effects of music

At present the only study concerned directly with emotional changes evoked by music in the context of personality reported increased positive activation following music exposure particularly among people with high Neuroticism and Anxiety scores (Kallinen and Ravaja, 2004). Therefore, people prone to be anxious and worried might benefit the most from musical activities.

In addition, experiencing "chills" during a musical exposure is found to be related to

Openness to Experience and Agreeableness and it is suggested that people who experience most chills are likely to be sensitive, emotionally responsive and socially agreeable (Panksepp and Bernatzky, 2002; McCrae, 2007).

The ways individuals choose to use music in their lives may also shed light into their susceptibility to music-induced emotions. It has been found, that individuals scoring high on Neuroticism are suggested to be more sensitive to emotion-moderating effects of music and use music to regulate emotions (Juslin and Laukka, 2003), with a preference for sad music, whereas Extraverts prefer cheerful music (Chamorro-Premuzic et al., 2010). A similar pattern has been observed also in a more general level with extraverts being prone to positive and neurotic individuals to negative affect (Matthews et al., 1990).

Moreover, individuals scoring high on Openness to Experience scale or IQ tend to use music in more cognitive/rational manner (that is, to analyze the structure of the composition or judge the performance) and their preference for classical and jazz music is more likely to reflect the intellectually stimulating complexity these people seek besides the emotional experience (Chamorro-Premuzic and Furnham, 2007). Cognitive use of music is also characteristic for people scoring high on Conscientiousness scales (Chamorro-Premuzic et al., 2010; Chamorro-Premuzic and Furnham, 2007). These findings do not necessarily mean that such individuals are emotionally less affected by music, even though it is possible, but perhaps is related to relatively higher emotional stability, in comparison to highly neurotic individuals, which decreases the need for external mood regulation.

1.5 Bayesian inference as an alternative to frequentist approach

"Surely, God loves the .06 nearly as much as the .05" (Rosnow and Rosenthal, 1989, p.1277).

The following section gives a brief overview on critique to the frequentist inference and advantages of Bayesian inference. As the latter is not (yet) widely used, this introduction was added to keep this thesis self-contained and clarify the reasons why the latter data analysis method is used in Chapter 2.

Recent debate about existence or non-existence of precognition has brought the problems and critique on how psychologists use statistical methods to analyze their data out of the circles of mathematical psychology where the discussion has been alive for a number years already. Wagenmakers' (2011) critique to Bem (2011) has resulted in null-hypothesis significance testing (NHST) critical articles being published in Cognitive Psychology and Journal of Personality and Social Psychology which, contrasting journals such as the Journal of Mathematical Psychology or the Psychometrika, do not usually publish methodological papers.

Using Bayesian inference instead of p-value null-hypothesis significance testing (NHST) has been proposed by several scientists (Jeffreys, 1961; Wagenmakers, 2007; Rouder et al., 2009). The discovery of Markov Chain Monte Carlo methods in late 80s, resolving many of the computational problems related to Bayesian inference, brought about an increasing use of Bayesian methods in machine learning and computer science (Fienberg, 2006), but not in psychology, as until recently using Bayesian hypothesis testing required quite advanced mathematical and computer skills. Fortunately, programs and toolboxes for some types of analyses have now been made available and the variety is growing, allowing the method to be used more widely.

1.5.1 Critique to the frequentist approach

Null-hypothesis significance testing (NHST) has been criticized for a long time for fundamental flaws psychologists are often not aware of, even though "the confusion between the two different procedures [Neyman-Pearson and Fischer] is now close to total" (Wagenmakers et al., 2008, p.183) and this "has rendered applications of classical statistical testing all but meaningless among applied researchers." (Hubbard and Bayarri, 2003, p.171). Some of the critical points are described below, for a detailed discussion see Abelson (1997); Rouder et al. (2009); Wagenmakers (2007); Lindley (1993).

First, NHST predicts probability of the data given the hypothesis. That is, it depends on data that was never observed and a hypothesis which may be true may get rejected because it failed to predict results that could have occurred, but did not (Jeffreys, 1961). For example, a frequentist 95% confidence interval for the normal mean μ in [-0.5, 1.0] does not mean that there is a 95% probability that μ is in [-0.5, 1.0]. Instead, it means, if the confidence intervals were constructed for different data sets, then in 95% of the cases would the true μ lie in the 95% confidence interval (Wagenmakers et al., 2008).

Second, the p-value does not quantify statistical evidence. If it did, it would mean that equal p-values would provide equal evidence. That is, the same p-values after 10 and 100 observations should constitute equal amount of evidence against the null-hypothesis. As the p-value is a function of the sample size, if the the p-values are equal, the observed effect size has to be larger with a smaller n (Abelson, 1997). Hence, contrary to the common belief that with larger sample sizes comes stronger evidence, there is more evidence against the null-hypothesis in the case of 10 observations.

Third, NHST does not allow for quantifying evidence in favour of null-hypothesis. That is, with the conventional methods it is impossible to draw a conclusion that there is no difference, it can only be said that one had failed to find support for the H_1. Sometimes it would be good to be able to show that there is no difference, between genders, for example – or in cases where no difference is expected, to not have to be satisfied with "not rejecting the null". If the null is false, significance tests work well – t-values increase with the sample size and this increases the probability of correctly rejecting the null hypothesis. With arbitrarily large sample sizes the t-value grows without bound and the p-value converges to zero. However, if the null is actually true, t-values do not converge to any limit and all p-values are equally likely – distributed uniformly between 0 and 1 – irrespective of the growing sample size (Rouder et al., 2009).

Fourth, p-values depend on possibly unknown intentions of various individuals, that is, it depends on the intentions for carrying out the experiment, the sampling plan. The way it should be calculated if we planned to ask a number of questions and stop after this number has been reached, differs from the case where we planned to ask questions until five errors occur. Or in the case we would consider testing more subjects, if the result we expected did not look like we wanted after the first inspection of the data. Or if we only had time and money to test additional subjects if our grant was renewed, which makes our p-value depend on the intention of the members of the grant committee. Therefore, p-values can only be reliably computed when the sampling plan is fully known and specified in advance (Wagenmakers, 2007).

1.5.2 Bayesian hypothesis testing

Rouder and colleagues (2009) along with others (Jeffreys, 1961; Kass and Raftery, 1995; Wagenmakers et al., 2008) advocate inference by Bayes factor (BF) instead of NHST. In contrast to the NHST, this method does not have the problems described in the preceding section. The Bayes factor allows straightforward interpretation of the result in terms of odds for the hypotheses compared - it quantifies the evidence the data provides for the models compared. For example, BF = 20 means that the null is 20 times more probable than the alternative, indicating strong evidence for H_0, while BF = 0.5 signifies anecdotal evidence for H_1 with the alternative only twice as probable as the null hypothesis (Wagenmakers et al., 2011).

Bayes' theorem in the simple form is given by the formula:

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)} \tag{1.1}$$

The posterior odds are calculated taking into account the prior odds and marginal likelihoods for both H_0 and H_1, where posterior probability $P(A|B)$ equals likelihood $P(B|A)$ times prior probability P(A) divided by marginal likelihood P(B) (Bayes and Price, 1763; Wagenmakers et al., 2010).

Prior probabilities are assigned by the researcher, based on their knowledge of the subject matter. Prior knowledge is updated based on the observed data resulting in posterior knowledge, that can again be used as prior knowledge for the next analysis (Wagenmakers et al., 2008). If nothing is known about the topic, it would be reasonable to choose an uniform prior distribution that assigns equal probability to every value of the parameter (Wagenmakers et al., 2010). If prior knowledge exists, more informative prior would be preferable, because priors that attribute undue mass to unreasonable parameters, would favour the null hypothesis (Rouder et al., 2009).

Prior distributions need to be specified for both effect size and variance. Prior odds at 1.0 is a position that does not favour neither of the hypotheses compared and is hence often used in practice. Alternatively, JZS prior (an acronym referring to Jeffreys, Zellner and Siow) as the standard objective prior for one and two samples cases uses Jeffreys prior on variance $p(\sigma^2) = 1/\sigma^2$ (Jeffreys, 1961) and Cauchy prior (a t-distribution with a single degree of freedom) on effect size (Rouder et al., 2009).

Bayesian approach has been criticized for being subjective, particularly what concerns choosing the priors. However, as Berger and Berry (1988, as cited in Rouder et al. (2009), p.235) point out: "Researchers willing to perform hypothesis testing must realize that the endeavor is inherently subjective." It is always the matter of the alternatives compared and being aware of this is important for both frequentists and Beyesians. In Bayesian analysis the subjectivity is transparent and hence paid more attention to (Wagenmakers et al., 2008). While trying to be objective and to choose not informative priors might seem the right way, it might not be the best, in case the prior knowledge on the prior distribution actually is available. For example in the case of human weight, choosing a prior with mean 0 and variance 10000 would hardly be reasonable - doing it does not make the test more "objective" (Wagenmakers et al., 2010).

There are several advantages in using Bayesian inference: it is based on the data that was actually observed. It does not depend on sample size or the intentions of the researcher; it enables assigning probabilities to hypotheses; it treats null hypothesis as equal to alternative hypothesis (Wagenmakers et al., 2008).

For these reasons, in this thesis Bayesian inference is used where appropriate in terms of the nature of the data and where respective applications are available making it computationally feasible, both of which apply only for Study 1. This approach was not adopted across all studies because computerized straight forward applications for Bayesian hypothesis testing are currently available only for parametric analyses and at least interval scale data, that is, not for ordinal scale data or repeated measures analysis, which were necessary for data analysis in the remaining studies. Moreover, as in study 1, given that we used a novel and difficult signal detection task and expected no difference between groups, conventional data analysis would have not allowed to quantify the evidence for "no difference" hypothesis, which is possible using Bayesian hypothesis testing, hence representing another advantage of this approach. However, the results of t-tests with p-values are also presented, as Bayesian methods are not yet widely used or known, and therefore, Bayes factors here offer merely additional information and aid in interpreting the results.

1.6 Outline of studies

This section gives a short overview of the rationale, hypotheses and results of the studies inlcuded in this thesis, followed by discussion and future directions. In this thesis the focus is on two of the mechanisms in the Juslin and Västfjäll (2008) model, through which music evokes emotions - musical expectancy and emotional contagion. The first two experiments focus on processing of one type of musical expectancy violation – out-of-key notes – and mechanisms through which this type of violations are detected by either musically trained or untrained individuals. The subsequent three experiments examine whether the mood elevating effect of music decreases the symptoms of depressed patients, whether the effect is specific to music, and whether individual differences, like personality, have an effect on how much music affects people.

Behavioural study

Detectability of musical scale violations in absence of prevalence and intervallic mismatch was investigated with an active listening task. Sensitivity to the violations was compared between sequences with and without melodic context as well as between musically trained and untrained individuals. Detectability was expected to be higher for the melodic context, based on additional available information in the melodic context, and for participants with musical training, based on stronger scale representations resulting from explicit musical knowledge and experience.

The results showed that the detectability of the notes violating the tonal expectancy was low even in the presence of melodic context. This contradicts previous findings, which suggest that the scale information is processed automatically on the level of auditory sensory memory (Brattico et al., 2006), which would imply that their detectability would remain high irrespective to the context, as the rules are built online. The current results suggest that the high detectability was rather due to the mismatch effects and not necessarily related to processing of scale information. The sensitivity (*d'*) of participants with or without musical training remained in the same range, indicating that explicit knowledge of musical rules did not improve the performance.

EEG study

This study expands on the findings by Brattico and colleagues (2006) with the aim to determine which mechanism is responsible for processing scale violations. In order to investigate this mechanism, we used a melody and a scrambled note sequence, in which the scale violations were matched for prevalence and preceding intervals (the same as in the behavioural study). In this way elicitation of mismatch effects was ruled out. Hence, a difference in neuroelectric activity between the out-of-key and control note would reflect processing of scale information at the level of music-syntactic analysis, which relies on pre-existing mental representations of the hierarchical structure underlying a scale in long-term memory.

The scale violations were neuroelectrically detected and elicited an ERAN in time-window 230-290 ms, even in the absence of mismatch in frequency of occurrence and preceding intervals. A difference based on musical training emerged, whereby in musically untrained individuals the presence of a melodic context played a crucial role in the detectability of the deviant notes; in contrast, in musicians the detectability did not depend on the context.

Depression case series

The aim of this study was to investigate whether weekly music-making sessions in small groups, without the cognitive component of music-therapeutic intervention, would improve the mood of depressed patients. Koelsch et al. (2010) used the same procedure with healthy individuals showing a mood elevating effect after only one session. This lets us expect a similar effect with patients suffering from low mood as they are still likely to respond emotionally to music (Gold et al., 2009).

The decrease of depression symptoms was marginally below the criterion for the reliable significant change, indicating no reliable reduction of depression. However, comparisons of pre- and post-session mood showed consistent decrease of Anxiety, Depression, and Fatigue and increase of Arousal and Positive Mood, suggesting an immediate positive effect of music-making, which could be used as a temporary relief and energizer.

Depression group comparison

The aim of this study was to investigate whether the mood-elevating effect of musical activities in depression patients, as reported in previous studies, is specific to music – or can be elicited by a similar non-musical activity. To answer this question we compared music-making to audio-book listening and picture-drawing tasks. The latter served as an active control intervention, which was chosen instead of a waiting list or treatment as usual control group, to control for non-specific increased activity effects. In line with previous findings, we expected the music-making to decrease the symptoms of depression more than the control activity and the mood to improve more in the music-making group in terms of decrease of Anxiety, Depression, and Fatigue and increase in Arousal and Positive mood, whereas in the control group a mild decrease of symptoms could also be expected as an effect of a pleasant activity.

Symptoms of depression decreased in both groups, revealing no significant differences between groups. Hence, based on current evidence, it can not be concluded, that the effect was music specific. However, comparison of the POMS scores before and after the intervention shows a trend, that music-making affects positively more aspects of mood than audio-book listening and therefore could be more beneficial, if only as a tool to improve mood temporarily.

Personality and music-making

The aim of this study was to investigate whether personality differences determine the extent to which healthy individuals are influenced by cheerful music. Based on previous findings it was hypothesized that individuals scoring high on Neuroticism, who naturally prefer to use music for emotional regulation, will be more susceptible to the mood elevating effect of music.

Anxiety, Depression, and Fatigue decreased whereas Arousal and Positive Mood increased after the music-making session. The direction of the change was as expected for all sub-scales and in accordance with previous findings (Chapters 4 and 5, Koelsch et al., 2010). Introversion was related to a decrease in Depression and Anxiety and increase in Positive mood. High Agreeableness was related to a decrease in Fatigue, whereas high Openness to Experience predicted increase in Fatigue and decrease in Arousal. Moreover, musical training was related to a number of positive changes – decrease in Depression and Fatigue and increase in Arousal and Positive mood. Liking of the accompanying music had an effect on changes in Depression, Anxiety, and Arousal.

1.6.1 Discussion and future directions

The present dissertation has contributed to advancing research on music and emotion in the following aspects:

Musical expectancy

It was demonstrated that musical scale violations are detected even if they do not differ from the in-key notes by frequency of occurrence or preceding intervals; the detection also occurs in absence of melodic context, which, however is more helpful to individuals without musical training.

It was demonstrated that musical scale violations are processed by activation of music-syntactic analysis, which relies on existing representations for scales in memory and not on on-line build up of a set of rules for a specific auditory context (auditory sensory memory), as the absence of intervallic and prevalence mismatch eliminates activation of the latter process.

These two findings show that even subtle scale violations are perceived as irregular events. It is possible that the emotional reaction evoked by this kind of expectancy violation is related to the degree of subtlety and salience of the violation. For example, increase in violations' distance from the prevalent key and occurrence in a mismatched context – as if the performer hit a wrong note – would increase the likelihood that the note is perceived as "wrong", which might evoke different degrees of irritation. Alternatively, if they are introduced in a way that makes their "wrongness" less salient and here perhaps the preceding intervals and distance on the Circle of Fifths play a more crucial role than prevalence, they might be perceived as "interesting", possibly signaling a modulation to a different key. In the current studies we used only scale violations closest to the prevalent key, hence leaving us unable to answer the question of the influence of distance. Testing this hypothesis in a future study, where the distance is varied could shed further light into how scale violations evoke emotional responses.

Emotional contagion

It was demonstrated that depressed patients benefit from the emotion-evoking effect of a musical activity, which brings about a decrease in anxiety, depression and fatigue, whereas arousal and positive mood increase. Even though the general effect on depression symptoms was not significantly larger in the group with musical activity in comparison to the control group, music affected more aspects of mood and seems therefore to be more beneficial.

The results do not allow to draw conclusions on the long-term effects of the intervention; therefore a study with a longer testing period before and after the intervention and with a more homogenous patient group could help to answer the question, whether music-making would reliably decrease the symptoms of depression, as previously shown by (Gold et al., 2009). Based on current findings, it can be concluded that on a short term basis, to elevate mood and activate the patients, music-making was beneficial and could contribute to a better quality of life on a daily basis. It is possible, that musical activities contribute to reducing the somatic symptoms and increase activation and energy, which can then be used to change the dysfunctional cognitive and environmental patterns that keep up the depression and for this reason music therapy could be most effective when provided together with a cognitive intervention. Further studies can determine whether musical and cognitive interventions together might be sufficiently efficient to, for example, reduce the need for additional antidepressant or anxiolytic medication.

As a limitation to these patient studies, it must be noted that patient information regarding their history and medication was partly based on their self-reports, therefore introducing some potential inaccuracy due to retrospective memory distortions. Moreover, all music-making sessions were conducted by the author, to eliminate the effect of different therapists. Yet, this does not completely eliminate the effect of a therapist, which may play a role in the overall improvement as a positive interaction for the patients. However, this effect is potentially very small in comparison to traditional music therapy studies where the involvement of the therapist in the whole process is larger. Presence of other group members provides social interaction, even if just through joint music-making and may also contribute to the improvement, which the current design does not allow to differentiate. However, in active music therapy there are always at least two individuals participating, so this setting is more naturalistic than letting them play alone. In one of the studies music-making was used together with music listening to increase the exposure and while it served this purpose well, it also means, that the results remain inconclusive in terms of the specific role of music-making or listening and show the cumulative effect.

It was demonstrated that music-making improved the mood of healthy individuals and that introverted participants were more likely to benefit from the mood elevating effect of music, supporting previous findings showing that introverts are more influenced by music (Cassidy and Macdonald, 2007; Furnham and Strbac, 2002) in terms of distractibility, which affected their performance in cognitive tasks and perhaps reflect an increased difficulty to ignore background music as they are more drawn to it than their extraverted.

Mood of the participants, who had had some musical training, improved more than their fellow participants' without musical training. This leaves, however, open the question whether this difference was due to the musical training, which increased their sensitivity to the mood elevating effect of music, or did individuals who already were more easily influenced by music choose to learn an instrument.

Therefore, another path for future studies could take a closer look at the emotion-inducing effect of music in professional musicians. This aspect has been neglected in research so far and little is known about changes musical training could cause in the brain areas related to processing emotions. It has been suggested, that performing professional musicians do not experience emotional effects of music in the same manner as amateur musicians or musically untrained people, as the areas of reward and emotion were not active in professional musicians during a performance of a piano concerto which usually is perceived as emotional (Parsons et al., 2005). This happens perhaps because expressing an emotion becomes more important than experiencing it and attention is focused on technical precision rather than enjoying ones own performance. Thus, it could be argued that losing the emotional pleasure music-making provides for the majority of individuals, is a vocational hazard professional musicians may face, but it is yet to be established whether this is the case.

Mood change in healthy and depressed individuals was qualitatively comparable, yet quantitatively changes were larger in individuals who were moderately depressed or healthy, but scoring higher on the depression scale, perhaps as their lower baseline mood allowed a larger improvement. In contrast, the few participants scoring high in clinical depression measures (and also having the longest history of depression) demonstrated little improvement, in line with the findings that severity of depression increases in time along with the difficulty to improve the condition due to various physiological changes brought about by the disorder (Harro and Oreland, 1996). Relatively less improvement showed also the healthy participants who were already in a good mood, as indeed, their mood was already good.

1.7 Publication plan

1. Behavioural study: Kalda, T., (under review). Musical scale violations have low detectability in absence of mismatch. *Music Perception.*

2. ERP study: Kalda, T. & Minati, L. (2012). Detecting scale violations in absence of mismatch requires music-syntactic analysis: A further look at the early right anterior negativity (ERAN). *Brain Topography, 25, 285 - 292.*

3. Depression case series: Kalda, T. & Cavanagh, K., (in preparation). Music-making with depressed patients: A case series. *Nordic Journal of Music Therapy.*

4. Depression group comparison: Kalda, T., Käbin, M., & Eller, T., (in preparation). Music-making with depression patients – Is the mood elevating effect specific to music? *Nordic Journal of Music Therapy.*

5. Music-making and personality: Kalda, T. & Raidvee, A. (under review). The role of personality in music-evoked mood change. *Psychology of Music.*

Chapter 2

Behavioural study: Musical scale violations have low detectability in absence of mismatch.

Abstract

In previous studies musical scale violations have been highly detectable, yet it remains unclear which characteristics of the stimuli are crucial for the detectability. This study investigates whether the high detectability of scale violations is preserved when the prevalence and preceding intervals of the out-of-key notes are matched with an in-key control note, and whether additional melodic structure aids in detecting the violations. In a behavioural experiment 66 healthy students with or without musical training listened to a sequence of notes with melodic context and to another sequence in which the notes were scrambled, with the task to actively detect the out-of-key notes. The results showed that the detectability of the notes violating the tonal expectancy was low. Moreover, adding melodic structure to the sequence did not improve the performance significantly. This suggests that previous reports of high detectability may be due to the low prevalence of the out-of-key notes and mismatch effects, leading to the activation of auditory sensory memory, and not necessarily a result of processing of scale information. The sensitivity (d') of participants with or without musical training was in the same range, indicating that explicit knowledge of musical rules did not improve the performance. The results suggest that removal of the mismatch and lowest prevalence of the out-of-key note decreases the detectability of the scale violations, which are likely to be detected by activating music-syntactic analysis, relying on representations in long-term memory instead of online

build-up of contextual rules.

2.1 Introduction

The rules Western tonal music is based on are implicitly learned by exposure at a relatively early age (Krumhansl, 2000; Tillmann et al., 2000) - four to five year old children show different neuroelectrical activity in response to violations of musical syntax, indicating that their implicit knowledge of the harmonic structure of Western music is present at that age (e.g. Jentschke et al., 2008).

One question that is still open to a debate is whether such implicitly learned rules are used to detect scale violations via engaging music-syntactic analysis and relying on the representations of the scale structure in long-term memory or whether the notes deviating from the scale expectancy are processed the same way as any change in a repetitive auditory environment by activating auditory sensory memory and constructing the rules based on the immediate context (Koelsch, 2009).

Scale violations have usually been introduced in melodies or in chords, making it impossible to differentiate between, for example, processing of melodic structure and tonal structure. Moreover, processing of musical syntax has been predominantly investigated using chord sequences (e.g., Koelsch et al., 2007; Jentschke et al., 2008; Bharucha and Stoeckig, 1986; Loui et al., 2005; Loui and Wessel, 2007), with remarkably fewer experiments using melodic stimuli to specifically investigate processing of scales (Brattico et al., 2006; Miranda and Ullman, 2007; Koelsch, 2010).

One of the possible underlying mechanisms, auditory sensory memory, is responsible for detecting changes in a repetitive auditory environment. The process is automatic and irrepressible, independent of attentional focus (Näätänen et al., 2007). That means, the detectability of changes that activate auditory sensory memory (like irregular pitch, amplitude, timbre (Näätänen et al., 1978; Schröger, 1996), or interval direction (Saarinen et al., 1992)) is in general high, as long as there is sufficient information to build a representation of the context before the deviant is presented. This, however, does not necessarily mean that the subjects are always aware of (or able to consciously detect) the deviants (Näätänen et al., 2007).

In contrast, music-syntactic analysis refers to the stage of auditory perception where structural elements such as tones, intervals or chords within their musical context are processed. It relies on the already existing representations of music-syntactic regularities in the long-term memory which are established through experience and strengthened by musical training (Koelsch, 2009; Koelsch et al., 2002; Loui and Wessel, 2007; Bigand et al., 1999). For example, people have implicit knowledge of transition probabilities for chords. In addition, musically trained individuals have explicit knowledge and due to more exposure, stronger representations (Loui and Wessel, 2007).

Brattico and colleagues (2006) suggested, that the auditory sensory memory would suffice to detect scale violations, however, in their stimuli the deviant notes were presented in a melodic context, which means that a melodic structure was available for the listener in addition to the scale information. Moreover, the deviant notes were induced in the note sequence always a semitone higher or lower from the preceding note while the intervals preceding the control notes varied in a larger range, and the prevalence of the out-of-key note was lower than for the control note, which could have brought about activation of auditory sensory memory as a response to low prevalence in addition or instead of scale violation.

In studies conducted to present, detectability of the deviant notes presented in melodies or chords has been high, as suggested by correct differentiation rates over 81% (e.g. Koelsch et al., 2005, 2007). Also, the scale violation subtest of the Montreal Battery of Evaluation of Amusia is based on the assumption, that out-of-key notes are easily detected in melodies by healthy individuals (Peretz et al., 2003), with a mean detection rate of 90% and 17% of participants scoring 100% correct. However, in many cases behavioural data characterizing the stimuli that were used are not provided, possibly because often passive listening tasks (where the participants are asked to attend to a different task, like reading or watching a movie) are used along with EEG recordings to minimize the effect of attention and to reduce motor artefacts (Loui et al., 2005; Koelsch, 2009). Even if the information of performance in an active task is available, detection rate alone is perhaps not the best parameter to compare the difficulty of a task across experiments even though it gives an estimate for the specific study. Hence, we decided to conduct a behavioural study to examine how detectability changes depending on the available information (i.e scale information alone vs added melodic context) when the mismatch effects are removed, and to use the sensitivity index (d') as a measure for the difficulty, as it takes into account both hit and false alarm rates – sensitivity index is calculated by dividing the strength of the signal by the amount of noise (Simpson and Fitter, 1973).

To investigate the detectability of scale violations in absence of mismatch in prevalence and preceding intervals, a behavioural experiment with an active listening task was conducted. Two sequences of notes were constructed matching the prevalence of the out-of-key and the control note and the intervals preceding both notes. This means that the out-of-key note was not with the lowest prevalence in the sequence and would therefore not be detected as an oddball for that reason. The preceding intervals were controlled in order to ensure, that the detection of the scale violations would not take place based on the online constructed regularities, relying on the online analysis of the inter-note relations. Otherwise, the detection could potentially still take place by analyzing the just heard intervals, which in case of the out-of-key notes could not have been in-key, if the following note was to be in-key. In addition, one of the sequences had melodic structure to control, whether instead of mismatch effects, the availability of melodic structure contributes to the detectability, as the latter allows predictions about continuation of the phrase as well as note-to-note (Rohrmeier and Koelsch, 2012).

Taking into account the previous findings and novel aspects of our stimuli, one of the following likely scenarios could be expected:

(1) If the detectability of the out-of-key notes was high in the sequence with the melodic structure and not in the scrambled sequence, this would support the hypothesis that availability of melodic structure information is crucial for detecting the deviants.

(2) If the detection rate was in the same range with the previous findings and did not differ between conditions, it would suggest that the mismatch in prevalence or preceding intervals does not play a major role in detecting the deviants and the tonal context is sufficient, that is, the decision is made based on the scale information.

(3) If, in comparison to the earlier findings, the detectability of the deviants would be poor in both conditions, irrespective to availability of melodic context, it would suggest that the critical discriminating factor contributing to the high sensitivity in the previous studies was probably the mismatch, which enabled detection of the deviants as oddballs, not processing of scale information as previously proposed by Brattico et al. (2006).

2.2 Method

2.2.1 Participants

Seventy volunteers were recruited from the University of Sussex participant pool. Four people were excluded from the analysis as outliers as their response pattern suggested they were responding randomly after every few notes. Median age for the remaining 66 participants was 20 years (range 18-48 years) and 13 were male. 43.3% of participants had had musical training (range 1 to 15 years, median 3 years).

The study was approved by the University of Sussex Ethics Committee (see Appendices A.1. and A.2. for the approval letter). All participants provided written informed consent after having been informed of the study purpose. The data was collected at the same session with the questionnaire part of the personality study (Chapter 6), so a joint information sheet was used (Appendix B.7.).

2.2.2 Stimuli

The prevalent scale was C-major and $F\sharp$ was chosen as the deviant out-of-key note. The subtlest deviant for C major was used in order to see whether the smallest difference is sufficient to be detected under the constructed conditions. All notes were taken from the two central octaves (A-A2). In-key and out-of-key triplets with identical interval structure were constructed, where out-of-key triplets ended on $F\sharp$ and in-key triplets ended on B (see panel (a) of Figure 1 for an example). The triplets were embedded into 46 15-note-long phrases, in which the out-of-key note was never the last one. Neither $F\sharp$ nor B occurred outside the triplets, ensuring that the prevalence of the deviant note would be matched to that of the control note, removing the possibility that detection would occur due to the lowest prevalence of the deviant. The phrases were synthesized using a Grand Piano voice and 400 ms-long notes with no pauses. Phrases were separated by alternating 400 ms or 1200 ms breaks. In six phrases, one note was replaced with a non-piano note serving as a timbre deviant and occurring approximately once per minute.

All phrases were composed so as to be perceived as meaningful melodies, with every fourth phrase ending on a C, and were played out in sequence, forming the melody condition. For the scrambled condition, the notes in the phrases were scrambled, while keeping the triplets intact. The resulting phrases were also played out in sequence, forming the scrambled condition. The frequency of occurrence of the notes and intervals was matched between the two conditions (p=1 and p=0.25 respectively) to remove potential confounds related to acoustic mismatch. The first two phrases for both conditions are shown in panel (b) of Figure 2.1.

2.2.3 Procedure

Participants were seated in front of a computer in a quiet room. Up to 5 participants were tested at a time. The task and essence of a musical scale were explained by the experimenter with a piano keyboard example, followed by listening to an example sequence consisting of ascending and descending C-major scale with A replaced with $A\sharp$ on the

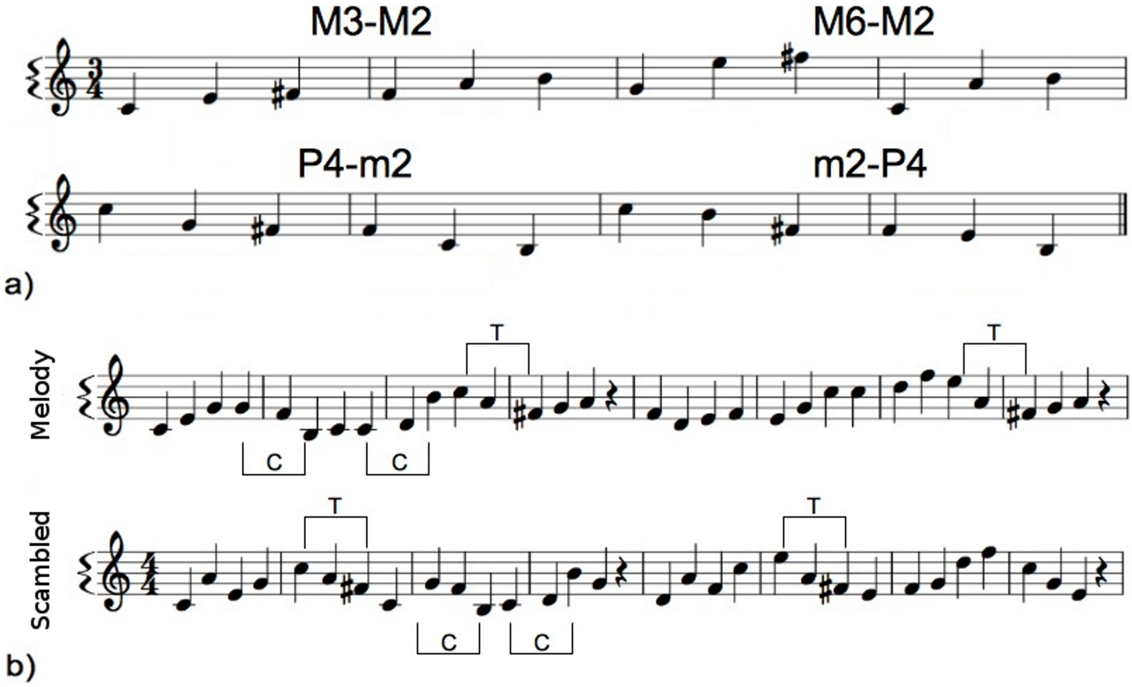

Figure 2.1: (a) Examples of Target and Control triplet pairs; M3 - major third; M2 - major third; M6: major sixth; m2 - minor second; P4 - perfect fourth. (b) Example phrases for both melody and random sequence. T - a triplet containing the deviant note $F\sharp$; C - a triplet containing the control note B.

ascending route and G and D replaced with $G\sharp$ and $D\sharp$ respectively on the descending route. The participants were instructed to adjust the volume in the headphones to a comfortable level at the beginning of the example and to press a button on the keyboard when they heard a note that they thought did not fit in well with the rest.

Subsequently both sequences of notes described in the *Stimuli* section were presented once using Presentation software and headphones. One half on the group listened first the melody sequence and second the scrambled one, for the other half of the participants the order was reversed. The listening task lasted approximately 12 minutes.

2.2.4 Data analysis

Responses up to 2000ms after the target were considered hits while all other responses counted as false alarms. As the sequence did not stop for the participant to respond after each note and every 400ms a new note was presented, we decided to use the response window instead of reaction times. The window was determined based on the distribution of the responses. As the majority of responses occurred inside this window, it was concluded, that the participants were responding to the stimulus. The longer than usual response time is likely to be due to the difficulty of the task resulting from the subtlety of the deviant stimulus. The distribution of the first responses after targets for 12 randomly selected participants is shown on Figure 2.2. They were selected using SPSS - Select cases - Select approximately 20 % of cases. Use of a response window instead of reaction times unavoidably introduces some subjectivity, which in this case is written into the stimulus design and can not be ignored, yet, as in naturalistic settings music usually flows while predictions are made and is not stopped for each of them, the goal was the best balance between ecological validity and minimizing subjectivity in data analysis.

Sensitivity quotient *d'* was calculated for each participant and condition. Based on the order of presentation, the sample was divided into two groups - Scrambled - Melody vs Melody - Scrambled, to examine whether presentation order had an impact on the performance.

Sensitivity quotient *d'* is an index widely used in signal detection theory enabling quantification of a signal in the noise. To compute *d'*, the z-score corresponding to the false alarm rate is subtracted from the z-score that corresponds to the hit rate (Stanislaw and Todorov, 1999). Hit rate is calculated by dividing the number of hits with the number of targets (here 46) and the false alarm rate is calculated dividing the number of false alarms with the number of non-targets presented (here 644).

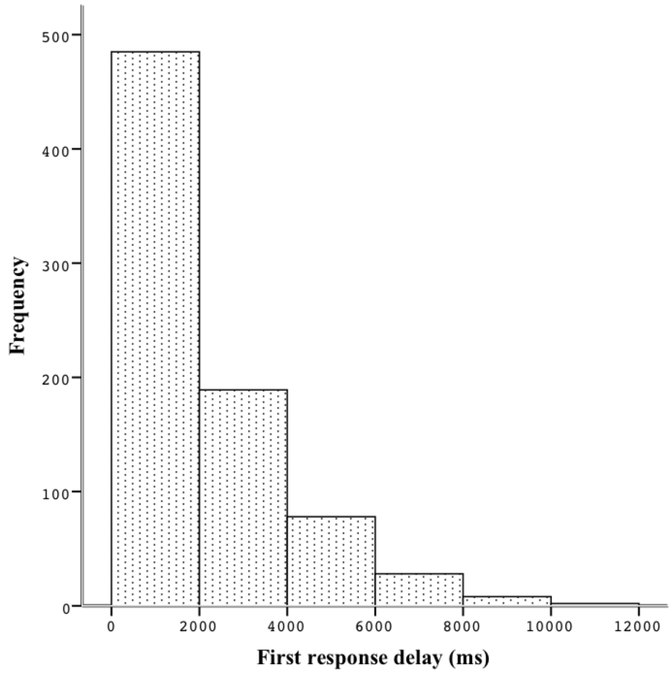

Figure 2.2: The distribution of first responses after the target notes. N = 790.

Independent samples t-test were conducted to compare the sensitivity in both conditions between groups and paired samples t-tests were used for within group comparisons. Subsequently, default Bayesian t-tests were computed using the web applet available at http://pcl.missouri.edu/bayesfactor (Rouder et al., 2009) to assess the strength of evidence for either difference or invariance. This method was chosen because null-hypothesis significance testing has recently been increasingly criticized for (among other problems) being dependent on the sample size and intentions of the researcher and not enabling the researchers to quantify evidence for null-hypothesis, that is for "no difference" (e.g. Wagenmakers et al., 2008). In cases where invariance is expected or quite likely, like novel discrimination tasks with the subtlest deviant, the option of being able to estimate the probability of H_0 being true would be of crucial importance. One relatively convenient way to overcome the above mentioned difficulties is to turn to Bayes inference and compute the Bayes factor. This would enable estimating the probability of either H_0 or H_1 which are treated equally, given the data - while in case of the conventional frequentist approach the inference is drawn regarding the probability of the data, given the null hypothesis. The latter leaves the researcher in the position where they may be left with the conclusion that the H_0 can not be rejected, but unable to tell, how likely it is that H_0 holds true.

The Bayes factor is directly interpretable in terms of odds for one of the hypothesis -

odds greater than 3 for H_0 (or smaller than 1 over 3 for H_1) are considered to represent "some evidence", greater than 10 for H_0 (or smaller than 1 over 10 for H_1) "strong evidence", and greater than 30 for H_0 (or smaller than 1 over 30 for H_1) "very strong evidence" (Rouder et al., 2009). In this light we decided to use Bayesian analysis where indifference is likely and it was not computationally exhaustive and for other analyses follow the conventional path.

The default version of the Bayesian t-test was used and posterior odds for JZS (an acronym referring to Jeffreys, Zellner and Siow) prior are reported. JZS is considered to be the objective prior for the one and two-sample cases, entertaining Cauchy prior on effect size and Jeffreys prior on variance (for further details see Rouder et al. (2009)). Of the two hypotheses compared to one another, H_0 stated that the mean sensitivity does not differ between the conditions or groups. H_1 stated that the mean sensitivity differs between conditions or groups. Additionally, a one-way ANOVA was computed to see whether having had musical training would influence the sensitivity. A post-hoc analysis was conducted to investigate whether there was an effect of learning. To that end the sensitivity was compared in the first and the last quarter (12 phrases) of both sequences for randomly selected 36 participants from both groups by computing repeated measures ANOVA with factors time (first 12 vs last 12) and condition (Melody vs Scrambled).

2.3 Results

Overall mean hit rate for the Scrambled sequence was 35.9% and false alarm rate 5.7%. For the Melody sequence mean hit rate was 32.7% and false alarm rate 5.1%. The data was normally distributed ($W{>}0.98, p{>}.68$) and the variance was homogenous ($W{>}0.92, p{>}.12$).

The mean numbers of hits and false alarms are given in the tables below where the first table (Table 2.1) shows the overall hits and false alarms for both conditions and groups and in the second table (Table 2.2) further divisions are made by whether the participant had had musical training or not.

The overall sensitivity in both conditions did not differ ($t(65) = 0.69, p = .50, BF_{01} = 8.2$). However, if the groups are considered separately, the detectability of the out-of-key notes in the Melody condition appears to depend on the presentation order and was significantly higher if the sequence with melodic structure was presented first, with the H_1 ca 90 times more probable ($BF_{01} = .011$, 1 over 90). In the Scrambled condition the H_0 was 5 times more probable ($BF_{01} = 5.3$), indicating that for the Scrambled sequence the order of presentation did not influence the performance (see Table 2.3 and Figure 2.3).

Table 2.1: *Mean number of hits and false alarms for both conditions.*

	Melody-Scrambled (N=33)	Scrambled - Melody (N=33)
	Mean (SD)	Mean (SD)
Scrambled		
Hits	16.4 (9.1)	16.7 (7.6)
False alarms	35.9 (25.9)	37.6 (20.1)
Melody		
Hits	17.7 (7.3)	12.4 (7.0)
False alarms	33.9 (23.5)	32.0 (21.4)

Table 2.2: *Mean number of hits and false alarms for both conditions and divided by musical training.*

	Melody-Scrambled		Scrambled - Melody	
Musical training	Yes (N=13)	No (N=20)	Yes (15)	No (18)
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Scrambled				
Hits	17.9 (8.0)	15.4 (9.7)	17.2 (7.6)	16.3 (7.7)
False alarms	41.1 (27.1)	32.4 (25.2)	35.9 (18.3)	39.1 (21.8)
Melody				
Hits	20.5 (7.8)	15.9 (6.5)	13.9 (6.4)	11.1 (7.4)
False alarms	37.9 (26.4)	31.4 (21.8)	33.3 (22.1)	30.9 (21.3)

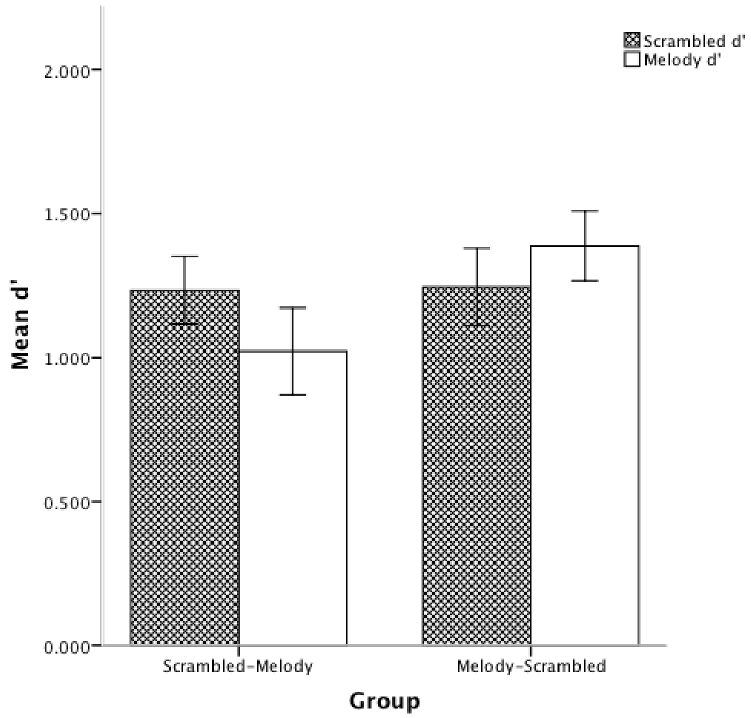

Figure 2.3: Mean sensitivity (*d'*) for both groups and conditions with 95% CI.

Table 2.3: *Between groups comparison for both conditions.*

Condition	t	df	p(2-tailed)	BF_{01}	Evidence category
Scrambled d'	.14	64	.89	5.3	Substantial (H_0)
Melody d'	-3.85	64	.00	.011	Very strong (H_1)

Within groups the sensitivity was significantly higher in the Scrambled condition if it was presented first, with the odds of 15 times for H_1 ($BF_{01} = 0.069$) , while the H_1 is ca .05 times more probable when the order was reversed, which indicates very weak support to H_1 (see Table 2.4).

Musical training had an impact on the performance in Melody condition ($F(1, 65) = 6.1, p = .016$) but there was no interaction between group and musical training. When the sample was divided based on previous musical training (any vs none), participants without musical training performed worse in the melody condition if they listened to the Scrambled sequence first ($F(1, 37) = 15.0, p < .001$). The overall performance, however, was similar (Figure 2.4). Musical training is here considered purely dichotomically, without taking

Table 2.4: *Inside group comparison for both conditions.*

Group	t	df	p(2-tailed)	BF_{01}	Evidence category
Scrambled-Melody	3.34	32	.002	0.069	Strong (H_1)
Melody-Scrambled	-2.12	32	.042	0.95	Anecdotal (H_1)

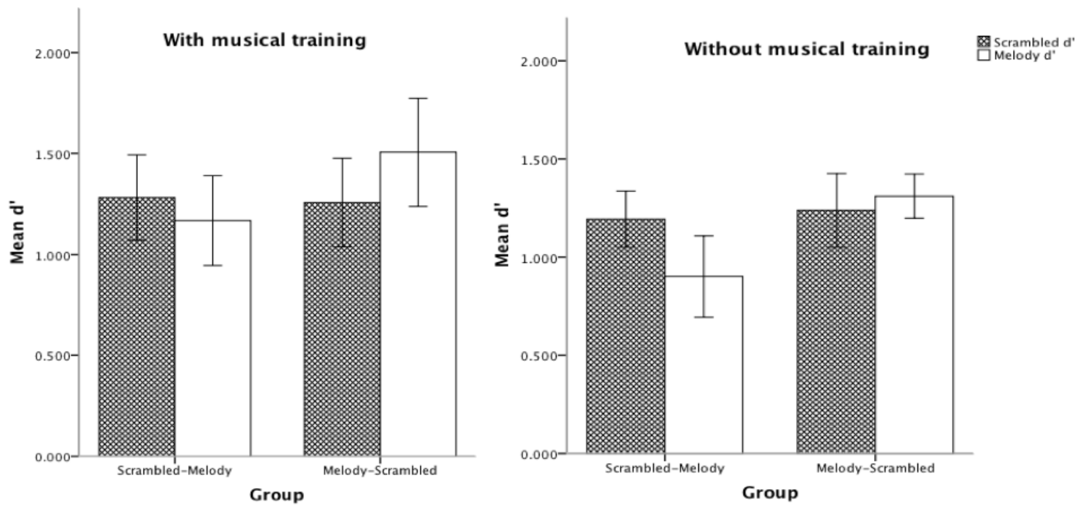

Figure 2.4: Mean sensitivity for participants with or without musical training with 95% CI.

into account the number of years, so it differentiates participants who have formal and explicit knowledge of musical rules and those who do not, but not between different levels of expertise.

Figure 2.5 shows that the performance decreased in the last quarter of the sequences, indicating that practice did not improve the detectability of the deviant notes. The performance was more stable in the group where Melody sequence was presented first. The decrease was larger in both groups for the sequence that was presented 1st, while the performance was best in the first quarter of the first sequence the subjects heard, possibly reflecting an effect of fatigue. The repeated measures ANOVA revealed an interaction between time, condition and group ($F(1, 34) = 8.4, p = .007, \eta^2 = .20$). A further division by group showed an interaction between time and condition for the Scrambled-Melody group ($F(1, 34) = 5.0, p = .04, \eta^2 = .23$) and the performance decreased significantly in the Scrambled condition ($F(1, 17) = 9.0, p = .008, \eta^2 = .35$), but not in the Melody con-

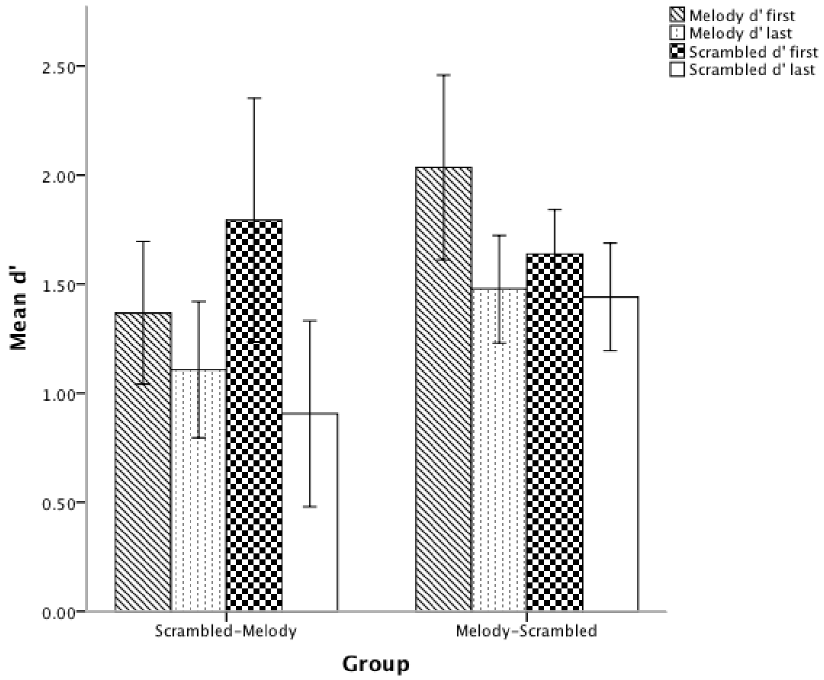

Figure 2.5: Mean sensitivity (*d'*) in the first and last 12 phrases for both groups and conditions with 95% CI.

dition. In the Melody-Scrambled group the interaction between time and condition was marginally not significant ($p = .08$), hence further divisions were not investigated.

2.4 Discussion

The aim of the present study was to investigate detectability of scale violations in absence of mismatch in prevalence and preceding intervals, to extend and complement previous studies where these aspects were not controlled for. In the stimuli used in previous studies, the out-of-key notes were introduced to a melodic sequence, where they had the lowest prevalence and the results showed high detectability (Brattico et al., 2006; Koelsch et al., 2005, 2007; Peretz et al., 2003).

Two aspects could have played a role in facilitating the detectability - first, the melodic context the deviants were presented in, and second, the low prevalence, which made the deviant stand out as oddballs. In current study, the stimuli were constructed to control for prevalence, intervals preceding the deviants and presence of melodic context. In such way it was possible to investigate which of the factors impact the detectability of scale violations.

From the three possible scenarios described above the last one proved to be the most plausible. The mean hit rate for both sequences did not differ significantly and varied between 30% and 39% suggesting that the task was rather difficult, even if the melodic context was available. These rates are low compared to the previously reported $80-98\%$ range (Koelsch et al., 2005, 2007; Peretz et al., 2003). This supports the hypothesis, that in the previous studies the main factor contributing to the high detectability was the mismatch in prevalence and possibly also preceding intervals, not necessarily the processing of scale information. Hence, while the observed response perhaps was an MMN, or MMN and ERAN, it was probably evoked by the mismatch and melodic context. Our data does not allow to disentangle the contribution of prevalence and the controlled preceding intervals - they together ensure that the observed detectability was not due to simple mismatch effects but processing of scale information. Moreover, the scale violation used was the subtlest possible, therefore it would be interesting to see, whether varying the distance on the Circle of Fifths impacts the detectability of the deviant notes.

We expected the order of presentation not to influence the detectability of the scale violations in either of the sequences. Thus, the finding that the order had an influence was somewhat surprising. However, the finding that the participants performed worse in the melody condition when the random sequence was presented first was a result of a decreased response rate, not increased false alarm rate - they gave fewer responses in general which resulted in decreases in both hit and false alarm rates. Though tentative, a possible explanation for this result could be that after hearing the random sequence the sequence with melodic structure was more pleasant to listen to. Also, as the out-of-key notes were not dissonant with the others (as two immediately preceding intervals were controlled for), they did not sound as incongruent, decreasing the number of responses.

It could be argued that participants without musical training had a disadvantage as they lacked the music-theoretical knowledge and therefore might have not understood the task equally well. However, as they performed roughly at the same level with participants who had had musical training in all other cases, it is unlikely to be the reason why their sensitivity was lower in the melody sequence after random sequence. Previous studies have also shown, that musically untrained people perform at large on the same level with musically trained individuals, as the rules are implicitly learned by exposure in early age (Krumhansl, 2000; Tillmann et al., 2000; Trainor and Trehub, 1994; Koelsch, 2009).

Since for both groups the detectability of the deviants was higher for the sequence the listeners were exposed to first, an alternative explanation could also be that after listening to the first sequence the concentration or motivation decreased which lead to a decreased performance in the second sequence. As the random sequence required more effort to listen to, fatigue might have biased the result for the melodic sequence while the effect was less severe in the group with reversed order. The comparison between sensitivity in the first and last quarter of the sequences also seems to support the explanation, that as the performance decreased in the last quarter, (instead of increasing, which would have indicated a learning effect), it could partially be due to decreased motivation or fatigue.

The finding that the sensitivity in the Scrambled sequence remained constant irrespective to group or condition, however, seems to contradict this explanation that the differences could just be explained by fatigue and lack of motivation, and draws attention to the fact, that changes take place when the melodic structure is present. This might be due to additional activated representations, that could perhaps, instead of facilitating the processing, inhibit it. A similar explanation has been previously proposed by Loui and Wessel (2007), who suggested, that automatically formed expectations can harm the performance in case of unexpected harmonies, particularly for individuals with musical training, for whom the representations are strengthened. Naturally, in that study the participants in the musicians group had had more training and melodies accompanied by chords could be considered more complex stimuli, still could be one reason, why sensitivity changes for the sequence with melodic structure and remains constant for the sequence without.

It can be concluded, that if mismatch in prevalence and preceding intervals is removed, the detectability of the scale violations is low, even if the melodic structure is present. This contradicts previous findings, suggesting that the scale information is processed automatically on the level of auditory sensory memory (Brattico et al., 2006), which would imply that their detectability would remain high irrespective to the context, as the rules are built online. The current results suggest that the high detectability was rather due to the mismatch effects and not necessarily related to processing of scale information.

Chapter 3

EEG study: Detecting scale violations in absence of mismatch requires music-syntactic analysis: a further look at the early right anterior negativity (ERAN)

Abstract

The purpose of this study was to determine whether infrequent scale violations in a sequence of in-key notes are detected when the deviants are matched for frequency of occurrence and preceding intervals with the control notes. We further investigated whether the detectability of scale violations is modulated by the presence of melodic context and by the level of musical training. Event related potentials (ERP) were recorded from 14 musicians and 13 non-musicians. In non-musicians, the out-of-key notes elicited an early right anterior negativity (ERAN), which appeared prominently over right frontal sites only when presented within structured sequences; no effects were found when the out-of-key notes were presented within scrambled sequences. In musicians, the out-of-key notes elicited a similar bilateral ERAN in structured and scrambled sequences. Our findings demonstrate that scale information is processed at the level of music-syntactic analysis, and that the detection of deviants does not require activation of auditory sensory memory by mismatch effects. Scales are perceived as a broader context, not just as online interval relations. Moreover, our findings indicate that additional melodic context information supports the

generation of neuroelectric responses to scale deviants in non-musicians, but is not essential for musically-trained individuals, likely as a consequence of stronger pre-existing representations.

3.1 Introduction

An outstanding question in music perception research is how tonal hierarchies, one of the key structures in Western music, are encoded and integrated. Previous experiments have demonstrated that structured musical stimuli are processed at multiple levels, involving associative auditory sensory memory as well as more abstract hierarchical representations of musical syntax Koelsch and Siebel (2005). These mechanisms are closely inter-related but at least partly anatomically and functionally dissociable Koelsch (2009).

In presence of a repetitive environment, the auditory sensory memory performs an 'online' analysis of ongoing stimuli, extracting regularities to efficiently compute predictions for future events. This type of processing takes place automatically and irrepressibly even outside the attentional focus, but inherently requires the presence of regularities that build up over a sufficiently long and dense stream of notes (e.g. Sams et al. (1985); Näätänen et al. (1989, 2007)). Stimuli violating the predictions generated by auditory sensory memory elicit a neuroelectric response known as the mismatch negativity (MMN), which usually peaks between 150 and 250 ms after stimulus onset, has negative polarity and largest amplitude at frontocentral and central sites Näätänen et al. (1978). Peak latency and amplitude are sensitive to the salience of the violation, and distinct MMN subtypes have been described, responding to low-level physical features (ph-MMN) such as frequency and timbre, as well as to violations of more abstract features (af-MMN) such as interval direction Saarinen et al. (1992). The neural generators of the MMN are located primarily in the superior temporal gyrus, with additional contributions from frontal areas Näätänen et al. (2007).

Concurrently, music-syntactic analysis relies on pre-existing representations of highly abstract tonal and harmonic structures Koelsch and Siebel (2005); Koelsch (2009), which are acquired at an early age (e.g. Trainor and Trehub (1994)). This type of processing subserves the detection of deviants that violate highly abstract rules, such as chords which, while harmonically and timbrically consistent with the preceding ones when considered in isolation, are perceived as unexpected within a chord sequence because they violate the cadence rules determining the probability for chords to follow each other. In contrast with auditory sensory memory, music-syntactic analysis does not rely on rules that are generated on-line through build-up of specific regularities within a given auditory context. Violations of the predictions generated by music syntactic analysis elicit a neuroelectric component which has negative polarity, peaks at about 180-350ms, is generally right-lateralized and therefore referred to as the early right anterior negativity (ERAN) Koelsch (2009). As for the MMN, the amplitude of the ERAN depends on the degree of violation; for example, very unexpected chords with a large degree of harmonic distance elicit a larger ERAN than do less unexpected chords Steinbeis et al. (2006). Furthermore, the ERAN can also be elicited by in-key cords that are music-syntactically irregular Koelsch and Jentschke (2008); Koelsch et al. (2007), and a similar potential can be evoked by music-syntactically regular notes in melodies Minati et al. (2008). In contrast with the MMN, the generators of the ERAN are located inferior frontal regions Maess et al. (2001).

While scale violations have frequently been used to investigate these processes, substantial controversy remains over the roles that auditory sensory memory and music-syntactic analysis have in detecting this type of irregularity. Addressing this question, Brattico et al. (2006) conducted a study where isolated notes in simple one-part melodies were made incongruent by altering their pitch to render them out-of-key, i.e. deviating from the diatonic scale, or out-of-tune, i.e. deviating from the equal-tempered chromatic scale. The authors reported an MMN effect, which was independent of attention and stronger for out-of-tune notes. One potential limitation of that study is that the deviant notes occurred much more infrequently than the corresponding control notes. As a consequence, they could have elicited an MMN effect simply in virtue of their perceptual salience, rather than as a result of the violation of abstract scale rules. Moreover, the deviant out-of-key notes were always a semitone away from the preceding note, whereas the intervals preceding the control notes were not controlled for, potentially leading to abstract-feature mismatching effects.

In order to complement and extend the findings of Brattico et al. (2006), we investigated a similar paradigm, in which minimal (1 step away on the Circle of Fifths) scale violations were introduced in the note sequences in a way that made them seem congruous with the immediately preceding context. The frequencies of occurrence of the deviant and control notes were matched, and the two intervals preceding both notes were controlled for, removing the possibility of effects related to incongruence. We hypothesized that this would reveal a residual ERAN effect not evident in Brattico et al. (2006), which would inherently represent the result of music-syntactic analysis, as in absence of incongruence and salience effects the predictions would have to be made based on the representation of a scale. Further, we hypothesized that this ERAN effect would be stronger when the control and deviant notes are presented in the context of a melodically meaningful tune rather than in a scrambled note sequence devoid of an obvious melodic contour, as the availability of additional melodic context might facilitate syntactic analysis Bigand et al. (1999). Finally, we hypothesized that this ERAN effect could be sensitive to the level of musical training of the participants, as musically-trained individuals have better-developed representations of abstract tonal rules Koelsch et al. (2000).

3.2 Method

3.2.1 Participants

Twenty-seven healthy volunteers were recruited for the study, which was approved by the University of Sussex Ethics Committee (see Appendix A.1. and A.2. for the approval letter). After having been informed of the study purpose (see Appendix B.1 and B.2 for the study information sheet.), all participants provided written informed consent.

The group of non-musicians consisted of 13 subjects aged 18-30 years (8 male, age 22 ± 3 years). 10 had never received any musical training beyond school education and the remaining 3 had played guitar or clarinet for less than 2 years more than 5 years before the experiment.

The group of musicians consisted of 14 subjects aged 19-35 years (6 male, age 25 ± 5 years), recruited from the University of Sussex Music Department, Orchestra and Big Band. Seven were pianists, 4 were violinists and the remaining 3 played wind instruments; 12 had started musical training before 7 years of age, and the remaining 2 had started musical training before the age of 10 years. None reported having perfect pitch.

All participants were right-handed according to the Edinburgh Handedness Inventory Oldfield (1971). None reported taking medication or suffering from psychiatric, neurological or hearing problems. Participation was remunerated with either course credits for psychology students or money for the other participants.

3.2.2 Stimuli and procedure

The prevalent scale was C-major and $F\sharp$ was chosen as the deviant out-of-key note. All notes were taken from the two central octaves (A-A2). In-key and out-of-key triplets with identical interval structure were constructed, where out-of-key triplets ended on $F\sharp$ and in-key triplets ended on B (see panel (a) of Figure 1 for an example). The triplets were

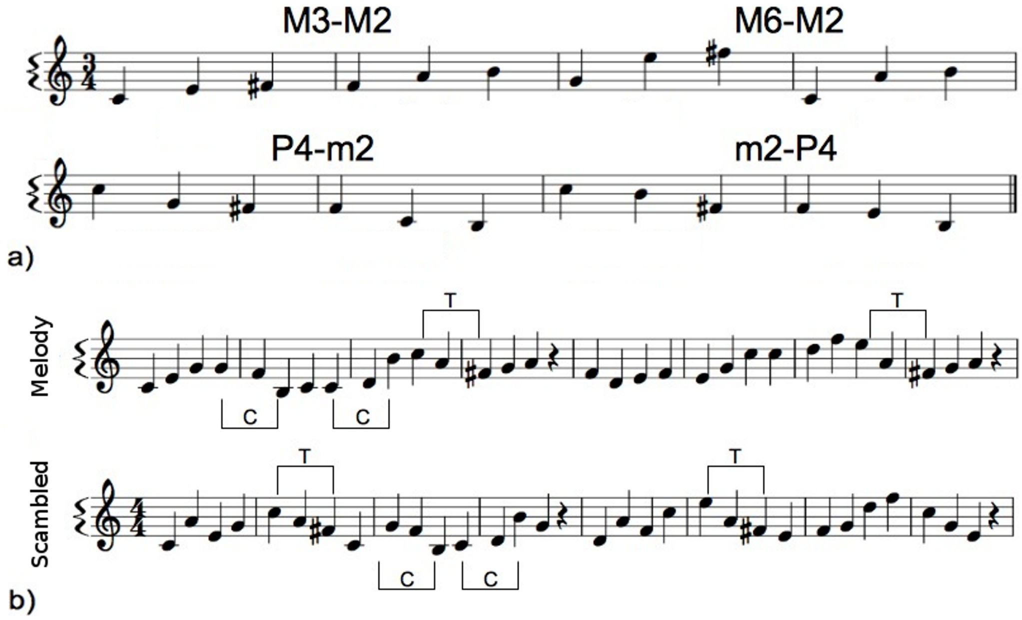

Figure 3.1: (a) Examples of Deviant and Control triplet pairs. Interval labels are indicated above the measures. M3: major third; M2: major second; M6: major sixth; P4: perfect fourth; m2: minor second. (b) Example phrases for melody and scrambled sequences. 'T' denotes triplets containing the deviant note $F\sharp$; 'C' denotes triplets containing the control note B.

embedded into 46 15-note-long phrases, in which the out-of-key note was never the last one. Neither $F\sharp$ nor B occurred outside the triplets, ensuring that the prevalence of the deviant note would be matched to that of the control note, removing the possibility that salience effects could elicit an MMN. The phrases were synthesized using a Grand Piano voice and 400 ms-long notes with no pauses. Phrases were separated by alternating 400 ms or 1200 ms breaks. In six phrases, one note was replaced with a non-piano note serving as a timbre deviant and occurring approximately once per minute.

All phrases were composed so as to be perceived as meaningful melodies, with every fourth phrase ending on a C, and were played out in sequence, forming the melody condition. For the scrambled condition, the notes in the phrases were scrambled, while keeping the triplets intact. The resulting phrases were also played out in sequence, forming the scrambled condition. The frequency of occurrence of the notes and intervals was matched between the two conditions (p=1 and p=0.25 respectively) to remove potential confounds related to acoustic mismatch. Overall, the melody and scrambled conditions were played out three times in alternating order, resulting in 138 presentations of the deviant and control notes in both melody and scrambled conditions. The first two phrases for both conditions are shown in panel (b) of Figure 3.1.

To estimate the conscious detectability of the deviant notes, 37 musically untrained students from the University of Sussex (mean age 20 ± 1 years, 8 male) listened to both sequences and were asked to press a button when they heard an out-of-key note. The average hit rate was 30% for the sequence with melodic structure (d' = 1.15) and 35% for the scrambled sequence (d' = 1.22), indicating that the detectability was low and the task was therefore rather difficult in comparison, for example, to the scale violation subtest of the Montreal Battery of Evaluation of Amusia, for which the mean detection rate is around 90% Peretz et al. (2003). None of these participants was also enrolled for the EEG recording session.

For EEG recordings the participants were seated in front of a computer screen in a sound-proof room and listened to the sequences via headphones. To maintain wakefulness and limit gaze wandering during EEG recording, participants watched a silent non-violent cartoon presented on 1/9th of a 13-inch screen positioned about 1 m away from the head. They were not informed about the scale violations in the sequences; rather, they were instructed to listen to the musical stimuli and respond to the notes with a deviant timbre by pressing a button. n other words, while the participants recruited for the behavioural test were instructed to detect the key deviants, the participants recruited for EEG recording performed a different, simpler task, i.e. detecting timbre deviants while acting as passive listeners with respect to the key deviants. This task was introduced to maintain attention to the auditory stimuli. They were not requested to detect key deviants to avoid potentially confounding effects related to motor response preparation and delivery. The recording session lasted approximately 35 minutes.

3.2.3 Data recording and analysis

The EEG was recorded from 64 scalp sites, referenced to the vertex, at a sampling rate of 500 Hz. Electrode impedances were kept under 5 kOhm. The data were resampled to 250 Hz, processed with a 30 Hz cut-off low-pass filter, and subsequently re-referenced to average. The signal was epoched between -50 to 400 ms with respect to note onset, and the pre-stimulus interval was used for baseline subtraction. Since the experimental hypotheses did not pertain to the deviant timbre stimuli, such notes were ignored for EEG analysis. The choice of a relatively short pre-stimulus baseline was motivated to reduce overlap with activity evoked by the previous stimulus given the brief inter-trial time. All epochs were visually inspected and epochs contaminated by eye-blinks, movements or other artefacts were rejected. On average, 21% of the original 138 trials were rejected, leaving 109 ± 16 per condition and note.

The averaging window for ERAN measurement was determined by inspecting the difference waveform, which was calculated between deviant and control notes across both conditions (melody, scrambled) and groups (musicians, non-musicians); this yielded a window at 230-290 ms post stimulus onset. In order to perform statistical analysis, four regions-of-interest (ROI) were defined on the scalp, and the mean amplitude values were computed grouping electrodes as follows: F1, F3, F5, FC1, FC3, FC5 for left anterior; F2, F4, F6, FC2, FC4, FC6 for right anterior; CP1, CP3, CP5, P1, P3, P5 for left posterior; and CP2, CP4, CP6, P2, P4, P6 for right posterior. Outliers more than 1.5 interquartile range away from the upper or lower quartile were rejected and replaced with the series mean. Repeated-measures full-factorial ANOVAs were computed with group (musicians vs non-musicians) as a between-subjects factor and hemisphere (left, right), anterior/posterior (anterior, posterior), condition (melody, scrambled) and note (deviant vs control) as within-subject factors. All significance values were Greenhouse-Geisser corrected.

3.3 Results

Behaviourally, all participants detected 5 or 6 out of the 6 timbre deviants with no more than 1-2 false alarms per sequence, indicating that the detectability of the timbre deviants was high and that the participants were attending to the musical stimuli.

Neuroelectric responses to in-key and out-of-key notes are shown in Figure 3.2: as expected, the out-of-key notes elicited an ERAN, which appeared prominently on the difference waveforms. Corresponding scalp maps for the 230-290 ms time-window are provided in Figure 3.3, separately for both conditions and groups. For non-musicians, in the melody condition the ERAN was clearly identifiable as a right-lateralized frontal negativity; in the scrambled condition, the ERAN was not apparent for this group. Conversely, for musicians the ERAN emerged as a bilateral frontal negativity regardless of condition.

Bar-charts of the mean amplitude difference between in-key and out-of-key notes under the four combinations of context and group are shown in Figure 3.4.

The statistical analysis was conducted with a hierarchical approach. An initial overall ANOVA was performed including factors for region (anterior/posterior), hemisphere (left/right), context (melody/scrambled), note (deviant/control) and group (musicians/non-

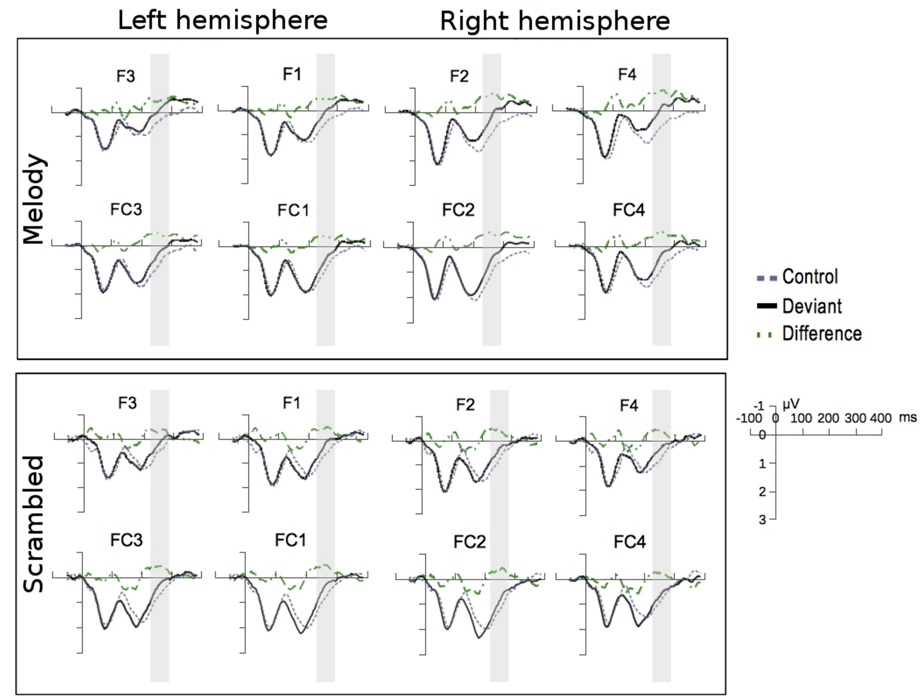

Figure 3.2: ERP responses to in-key and out-of-key notes with difference waves for all participants (i.e., musicians and non-musicians) and conditions at frontal and fronto-central electrodes. Grey rectangles represent the time-window used for ERAN measurement. The difference observed around 100 ms was not associated with any statistically-significant effect.

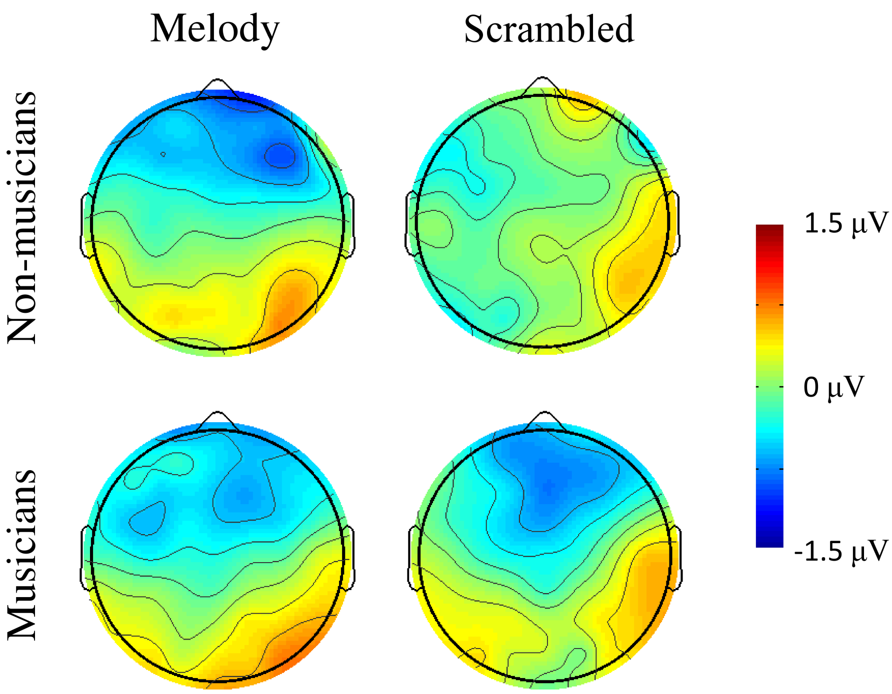

Figure 3.3: ERAN (230-290 ms) topographic maps, representing difference ERPs between in-key and out-of-key notes, for both conditions and groups.

musicians). This analysis revealed region $\times$ note ($F(1,25) = 30.9, p < .001, \eta_p^2 = 0.55$) and region $\times$ side $\times$ note ($F(1,25) = 7, p = 0.01, \eta_p^2 = 0.22$) interactions. On this basis, separate ANOVAs were performed for the anterior and posterior regions.

The ANOVA for the posterior region (having factors for hemisphere, context, note and group) revealed a main effect of note (more positive potential for deviants; $F(1,25) = 14.5, p < 0.001, \eta_p^2 = 0.37$), without any effect of context or group. By contrast, the ANOVA for the anterior region highlighted a hemisphere $\times$ context $\times$ note $\times$ group interaction ($F(1,25) = 4.8, p = 0.038, \eta_p^2 = 0.16$). On this basis, separate ANOVAs were performed for the anterior region for musicians and non-musicians.

The ANOVA for non-musicians revealed a main effect of note (more negative potential for deviants; $F(1,12) = 22.4, p < 0.001, \eta_p^2 = 0.65$), a context $\times$ note interaction ($F(1,12) = 6.1, p = 0.03, \eta_p^2 = 0.34$) and a side $\times$ context $\times$ note interaction ($F(1,12) = 6.7, p = 0.02, \eta_p^2 = 0.36$). The left and right sides were therefore analyzed separately. The ANOVA for the left hemisphere highlighted a main effect of note ($F(1,12) = 16.6, p = 0.002, \eta_p^2 = 0.58$) without any effect of context. On the right side, there was a similar main effect of note ($F(1,12) = 9.9, p = 0.008, \eta_p^2 = 0.45$) which, however, was accompanied by a significant context $\times$ note interaction ($F(1,12) = 12.3, p = 0.004, \eta_p^2 = 0.51$):

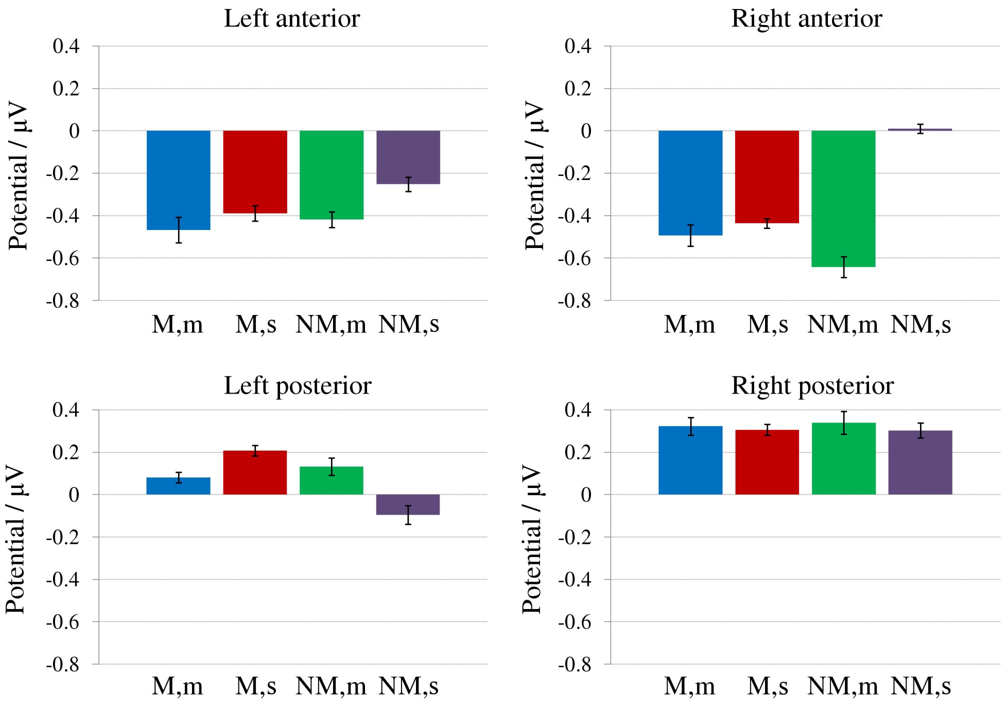

Figure 3.4: Bar charts of mean ERAN amplitude for both conditions and groups. Values denote difference ERPs between in-key and out-of-key notes. 'M': musicians, 'NM': non-musicians, 'm': melody condition, 's': scambled condition. The error bars represent standard error.

post-hoc ANOVAs indicated that the effect of note was present for melodic sequences ($F(1,12) = 13.3, p = 0.003, \eta_p^2 = 0.53$) and absent in scrambled sequences ($p = 0.9$).

The ANOVA for musicians revealed a main effect of note (more negative potential for deviants; $F(1,12) = 19.6, p = 0.001, \eta_p^2 = 0.60$), without any effect of context or side.

3.4 Discussion

This study addressed the question whether subtle scale violations could be detected even in the absence of any element of mismatch, which would lead to activation of auditory sensory memory: the control and deviant notes were matched for frequency of occurrence and preceding intervals, intrinsically removing the possibility of eliciting an MMN. The protocol therefore enabled us to specifically assess the activation of music-syntactic analysis, reflected in the ERAN. The principal findings of this study were that i) out-of-key notes could be neuroelectrically detected even in the absence of mismatch in frequency of occurrence and preceding intervals, ii) in non-musicians, the effect was only found when the out-of-key notes were presented within the context of a melodic sequence, and iii) in musicians, the effect was always detectable regardless of whether the sequence provided a melodic context or not.

Our study conceptually extends previous work on the ERAN elicited by harmonic incongruence (Koelsch and Siebel, 2005; Koelsch, 2009; Koelsch and Jentschke, 2008; Koelsch et al., 2007, 2000, 2002), and work on the scale information processing by (Brattico et al., 2006) by disentangling scale information processing from melodic and harmonic processing, which so far have been investigated together, leaving open the question whether auditory sensory memory or music-syntactic analysis is responsible for detecting scale violations.

Auditory sensory memory, which relies on short-term memory (Näätänen et al., 2007), supports the initial detection of inter-sound irregularities, indexed by the MMN, and provides the basis for learning more complex rules, such as scale and harmonic hierarchies. Such hierarchically structured representations are stored in long-term memory, which supports more abstract monitoring of ongoing note streams, activating specific context-dependent expectations related, for example, to harmonic features (Koelsch, 2009).

In the previous study by Brattico et al. (2006), the out-of-key notes were incongruous with the immediate context and had a lower frequency of occurrence than the control notes. As a consequence, auditory sensory memory activation (indexed by the MMN) was detected, not necessarily due to scale violations per-se. Our results extend these findings, demonstrating that activation of auditory sensory memory is not sufficient for the detection of scale violations, which is rather performed through music-syntactic analysis, acting on the basis of pre-existing, implicit knowledge about tonality rules instead of on-line analysis of regularities. This process elicited an ERAN which, as expected, was characterized by frontal distribution, in contrast with the more posterior frontal-central-temporal distribution expected for the MMN. Remarkably, the out-of-key notes were detected even though $F\sharp$ is the closest deviant note to C major, rendering the scale violation rather subtle; even though our data do not support inferences in this regard, more distant deviants could have led to stronger results Tillmann et al. (2000).

In the group of musically-untrained individuals, the out-of-key notes elicited an ERAN only when presented within a melodic context. The potential was observable at the right anterior electrodes, at latencies in agreement with previous studies on the ERAN Koelsch and Jentschke (2008); Leino et al. (2007). This differential effect signals that in the absence of musical training, additional melodic context information is required for successful identification of these violations. By contrast, in musicians the ERAN potential was equally elicited by deviants presented in melodic and scrambled sequences. Besides enhanced implicit knowledge of the music-syntactic rules, musically-trained individuals can also access their explicit knowledge of tonal regularities. The degree of explicit knowledge used remains, however, unclear as we used a passive task where they were not actively asked to detect deviants. The degree of explicit knowledge used remains, however, unclear as during EEG recording participants were asked to detect and respond to timbre deviants, which were unrelated to the key deviants.

Whereas in non-musicians the ERAN was clearly right-lateralized, in musicians it appears bilateral under both conditions, as revealed by ANOVAs as well as topographical maps. This is in line with previous studies, such as Koelsch (2009); Steinbeis et al. (2006); Koelsch et al. (2002); Minati et al. (2009); Loui et al. (2005), even though groups differences have not always been reported, likely as a consequence of small effect size. Even though a definite demonstration of the nature of this laterality effect remains elusive, a speculative interpretation is that it reflects the additional engagement of contralateral (i.e., left hemisphere) resources, i.e. more topographically widespread representations of musical rules in individuals with an extensive musical training. On the basis of our data alone, definite conclusions regarding this effect cannot be reached.

In our data, the ERAN peaked between 230 and 290 ms post-stimulus whereas in earlier work, such as the seminal magnetoencephalography study by (Maess et al., 2001), it generally peaked earlier, around 200 ms. As it is well-established that the latency of both

ERAN and MMN reflects the salience of the violation (Koelsch, 2009; Näätänen et al., 2007; Saarinen et al., 1992; Steinbeis et al., 2006), this discrepancy most likely reflects the fact that the key violations occurring in this experiment were rather subtle.

This study was limited in that a comparatively small number of channels was available, and source localization was not performed. Further, more advanced analyses representing microstates, global field power, spectral changes and topographical dissimilarities such as those outlined in (Michel, 2009) could likely have provided additional insight.

Another issue is that, since the group effect was relatively subtle, and no longitudinal or correlational analyses were performed, we cannot definitely exclude that the difference observed between musicians and non-musicians could be due to sampling effects.

3.5 Conclusions

In conclusion, the results of this study demonstrate that subtle scale violations can be detected even in absence of mismatch in frequency of occurrence or preceding intervals. This result fundamentally extends previous work, avoiding activation of auditory sensory memory by mismatch and thereby explicitly revealing the contribution of music-synctactic analysis to the processing of scale information. That is, instead of generating a system of regularities on-line based on relations between notes, a general pre-existing representation of the scale is used. This general representation can, for example, aid singers predicting the next note while reading music in a harmonically complex environment where the calculation of specific interval relations would not be feasible. While we are unable to conclude whether the deviants were consciously detected, statistically-robust effects were obtained for the ERAN. Interestingly, our results further indicate that additional melodic context information supports the generation of neuroelectric responses to scale deviants in non-musicians, but is not essential for musically-trained individuals, likely as a consequence of stronger pre-existing representations.

Acknowledgements

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LM contributed to the data processing and editing the final version of the manuscript before the submission for publication and produced the topographic maps.

Chapter 4

Depression case series: Does music-making help depressed patients?

Abstract

Music is widely used to elevate mood and a number of behavioural and imaging studies have shown the effects of music on mood of healthy individuals. Even though evidence for the effectiveness of music in therapy of depression is growing, a variety of methods used does not allow to distinguish the role of music from other therapeutic processes in the demonstrated effect. To address this issue and investigate the effect of music-making on the symptoms of depression, we used weekly structured music-making sessions in small groups with the procedure kept constant and the role of the experimenter minimal, alongside with daily self-administered music listening sessions with five adult non-musician patients (two male, three female, age range 29 to 61). Hamilton Depression Rating Scale (HAMD) interview was conducted at the start and end of the intervention. Beck Depression Inventory (BDI) and Profile of Mood States (POMS) were used to monitor mood before and after each session. The decrease of depression symptoms was marginally below the criterion for the clinically significant change, indicating no reliable reduction of depression. However, comparisons of pre-post music-making session mood showed consistent decrease of Anxiety, Depression, and Fatigue and increase of Arousal and Positive Mood, suggesting an immediate positive effect of music-making which could be used as a temporary relief and energizer, to decrease the suffering related to depression.

4.1 Introduction

Depression is the most common mental disorder affecting about 121 million people worldwide and the numbers are expected to increase making it one of the world's greatest public health problem. Around 16% of the population is affected at some time in their lives (e.g. Kessler et al., 2003; Scott and Dickey, 2003; WHO, 2010). Depression is associated with increased morbidity and reduced life expectancy and depressed subjects are significantly more likely to commit suicide (e.g. Isometsä et al., 1994).

Depression belongs to affective disorders and is characterized by low mood, decreased energy and enjoyment, hopelessness, reduced interests and increased fatigue, along with disturbed sleep, appetite and other somatic symptoms (ICD-10, 2011). Three categories of depression are distinguished by the number and severity of symptoms - mild (two-three symptoms, patient is able to carry on their daily activities), moderate (four or more symptoms, difficulties with continuing ordinary activities), and severe (several symptoms in distressing degree, usually unable to complete their daily tasks) (ICD-10, 2011).

Various treatments are available including medication and psychotherapies but fewer than 25% of the affected individuals have access to these therapies (Kessler et al., 2003; WHO, 2010). Psychotherapy is expensive and limited in availability leaving people to wait for periods of time before they can be treated. Antidepressants are found to be not as effective as previously assumed in mild to moderate levels of depression (Kirsch et al., 2008) and may show unpleasant side-effects which decrease treatment compliance. A recent meta-analysis has revealed overestimations also in the efficacy of psychotherapy due to inclusion of low quality studies in earlier meta-analyses, which showed significantly higher effect sizes than high quality studies (Cuijpers et al., 2010).

Considering the growing population of people suffering from depression and problems with currently available treatments, it is evident that there is a need for new treatments that would be less costly and free from adverse side-effects. Music therapy could be one of the alternative or complementary treatments to improve the quality of life and decrease suffering caused by depressive disorders. It has been used to help people with various problems for decades – the first music therapy degree program in the world was founded in 1944 at Michigan State University, signifying the start of music therapy as a profession (American Music Therapy Association, 2011). The scientific evidence for its efficacy is scarce, particularly what concerns classical music therapy (e.g. Edwards, 2005). Only in recent years has the research focused on the underlying mechanisms of the beneficial effects of music motivated by the increasing demand for evidence that would allow the health care systems to accept music therapy as one of the alternatives for the conventional therapies (Edwards, 2005).

It is generally accepted that music can be used and is widely used to induce emotions (e.g. Juslin and Västfjäll, 2008). Several studies have demonstrated activation in response to music in brain areas responsible for emotion and reward, involving parahippocampal gyrus, ventral and dorsal striatum, amygdala, and hippocampus (e.g. Gosselin et al., 2006, 2007; Mitterschiffthaler et al., 2007; Blood and Zatorre, 2001; Brown et al., 2004) and the ability of music to influence brain plasticity even after a relatively short exposure (e.g. Wan and Schlaug, 2010; Lappe et al., 2008).Lappe et al. (2008) demonstrated significant plastic reorganizational changes in the auditory cortex after only 200 minutes of musical training in comparison to music listening, where the changes were less pronounced.

Notably, decrease of hippocampal volume has been reported in relations to recurrent depression and a reversal of this process as a result of antidepressant treatment (e.g., Wager-Smith and Markou, 2011; Videbech and Ravnkilde, 2004; Boldrini et al., 2009), even though there have also been contradictory finings on this account, questioning the robustness of these findings (Hanson et al., 2011).

Nevertheless, increased activation of the affected areas by a musical activity could therefore possibly contribute to the recovery, which could explain the positive effect of music therapy. The findings, that music has an effect on brain plasticity and that musical tasks can activate a wide range of brain areas, has encouraged research on the use of music in order to elevate mood (Aldridge et al., 2005; Erkkilä et al., 2011; Gold et al., 2009) and overcome cognitive and motor dysfunction (Särkämö et al., 2008; Schlaug et al., 2008; Altenmüller et al., 2009).

Music can be used in therapy in a passive/receptive form, where the key component is listening to music, or active form, which is based on various music-making activities (Bruscia, 1998). Listening to music has been found to decrease depressive symptoms in a number of studies (e.g., (Särkämö et al., 2008; Hsu and Lai, 2004)), however, Chan et al. (2011) in their recent review emphasize the need for further studies for more accurate meta-analysis and the importance of repeated exposure due to the cumulative effect of musical activities, supporting the conclusions of Gold et al. (2009). The design used by Särkämö et al. (2008) prescribed one hour of music listening daily for patients showing depressive symptoms after a stroke and the positive effect was still present three months after the intervention.

An advantage of music-making over passive listening is participant's increased activity and involvement, which gives grounds to expect a stronger effect, but also sets limits to the applicability, assuming among other things greater motivation, more movement-, and coordination ability from the patient (Maratos et al., 2009), the last becoming a problem predominantly with patients with physical limitations, which is usually not the case with depression patients.

In the classical music therapy studies the therapeutic relationship between the therapist and the patient plays a crucial role (Maratos et al., 2009; Bruscia, 1991) along with verbal reflections and discussions based on the music. This feature makes it impossible to differentiate the effect of music from the effect of other components like the therapeutic relationship or reflections. It could be argued that it is unnecessary to take into parts something that seems to work. However, for a method to be evidence based, it is good to know that it works, but even better would be to know how and what about it works. Based on the evidence available, it remains unclear whether music is the main influential part of music therapy or might it just be a tool to aid communication, for example, even though studies using self-administered listening seem to support independent effect of music. Therefore, to see whether music alone has a positive effect on the symptoms of depression, we conducted a study where music-making was the main activity - the whole communication occurred through music and the experimenter had a minimal role - and it was supported by music listening to increase the dose of music in the intervention.

The aim of this study was to investigate whether weekly music-making session in small groups without additional therapeutic interaction improves the mood of participants who had previously been diagnosed with depression. Koelsch et al. (2010) used the same procedure with healthy individuals showing a mood elevating effect after only one session. This lets us expect a similar effect with patients suffering from low mood as they are still likely to respond emotionally to music (Gold et al., 2009) even though there are changes related to perceiving emotions in music and musical preferences in depressed individuals, demonstrating a bias towards negative stimuli and mood-congruent music (Naranjo et al., 2011; Punkanen et al., 2011). Given the novelty of the method, we adopted the case series approach to explore the possible benefits of this type of intervention. This is also in line with the progressive model of clinical research for psychological treatments where clinical observations should lead to case studies followed by controlled clinical trials (Agras and Berkowitz, 1980). We hypothesize that the patients' mood has improved after music-making and listening sessions and that after completing the course of sessions the symptoms of depression have decreased.

4.2 Method

4.2.1 Participants

Participants were recruited through primary care in the UK. All involved clinicians were informed about the inclusion (diagnosed with mild to moderate depression) and exclusion criteria (other psychiatric diagnoses, neurological, immunological problems, recent/present viral infection, substance abuse), asked to conduct the pre-selection by conducting the 9-item Patient Health Questionnaire (PHQ-9, Kroenke et al., 2001), and inform patients scoring 10 or above about the study. Patients were asked to contact the researchers via phone or e-mail if they were interested in participating. When they did, additional information was given regarding the study and an appointment was made for the introductory interview. Information about diagnosis and medication history is based on the patient's self-report. The evaluation of depression severity and respective categorization are based on HAMD and BDI scores (category boundaries are described in the Outcome measures section below). Where the two measures indicate different categories, prevalence is given to the HAMD, as it allows acquisition of more thorough information compared to the BDI questionnaire, where patients may over- or underestimate the severity of their symptoms (which is usually revealed in the interview, as patients like to elaborate on the questionnaire items and explain the ratings they gave).

This study was approved by the Brighton East Research Ethics Committee (registration number 08/H1107/131, Appendices A.3-A.6).

Participant 1 (M1)

Participant 1 was a 45 years old man with 10-year history of depression. His current medication was 20mg Citalopram and he reported having taken it since 2003. He had tried other medication and counselling which had not brought about lasting remission. He lived alone and had little contact with his family. Social contact were limited to a few friends. He had a university degree, but due to his condition gave up work a few years ago and was attending a part-time post-graduate course at the time of the study. He had not had any musical training. At the introductory interview he scored 22 on BDI and 17 on HAMD, which both indicate less than major depression.

Participant 2 (M2)

Participant 2 was a 61 years old man who reported suffering from low mood for the last 3 months following a stressful event. A few weeks before the study started he got 20mg Citalopram prescribed by his GP and he stopped taking his medication 3 weeks before the study finished. He reported loss of interests during the last few years and some mild cognitive problems were also evident from the interview (word finding/understanding, orientation in the space, memory). He lived alone, was retired and had a child with whom he had good contact. He had self-taught and played a string instrument for the last 20 years. At the introductory interview he scored 11 on BDI and 9 on HAMD, which both indicate minor depression.

Participant 3 (F1)

Participant 3 was a 44 years old woman with 4-year history of depression. She had taken antidepressants for the last 6 months but could not tell the name or dosage. She stopped working for 2 years and started again full-time 2 months prior to the start of the study. She lived in a house-share and had not had musical training. At the introductory interview she scored 14 on BDI and 25 on HAMD, which show a category discrepancy between the measures, but considering the interview results is categorized as having major depression.

Participant 4 (F2)

Participant 4 was a 29 years old woman with 4-year history of depression. The current episode started 1.5 years ago and for the last 7 months she had taken 20-40mg Fluoxetine. She had music lessons for 5 years as a child. She had a university degree, was taking a post-graduate course and lived alone. At the introductory interview she scored 34 on BDI and 21 on HAMD, which indicates major depression.

Participant 5 (F3)

Participant 5 was a 29 years old woman who had been diagnosed with depression at the age of 14 years. She had been on antidepressant drugs for three short time periods in the past and spent three weeks in a psychiatric hospital at age 18. She was currently off medication by choice and had started an undergraduate course at a University. She lived with her partner of 10 years and had had some years of piano and violin training. At the introductory interview she scored 16 on BDI and 21 on HAMD, which also show a discrepancy between the measures, but according to the HAMD score is categorized as having major depression.

4.2.2 Design

A single-case series study was conducted using A-B design with follow-up assessments. Each individual served as its own control. Non-treatment baseline lasted at least one week, with 2-4 measurements during this period.

In single-case designs evidence accumulates in a form of observed replication of the effects in the subsequent cases. Repeated measurements allow observations of the dynamics of the change process for each individual patient significantly better than designs relying of group means would (Barker et al., 2002), being therefore appropriate for the goals of this study.

As patient sample was used, particular consideration was given to ethical concerns. The session schedule was adjusted so that it was convenient for everybody to attend. The time and the venue were chosen so that it did not unnecessarily compromise their anonymity. Weekly sessions are usual practice in both psychotherapy and music therapy. Musical interventions vary significantly in intensity and it is not rare for them to span over several months (e.g., Särkämö et al. 2008, with daily 1-hour sessions over a 2-months period). In comparison, the intensity of the design used in this study was much lower and hence, we assumed, was not likely to cause major disruption or burden for the participants. Also, it was emphasized, that they are free to discontinue their participation at any time should they wish to and that their participation in the study would in no way affect their usual care from health services. Suicide risk was assessed during the introductory interview and in case of any immediate danger, there was a psychiatrist assigned TK could have contacted for consultation regarding further necessary actions. No such incident occurred. The questionnaires used were rather short and required little effort to fill in, taking not more than 15 minutes per session, therefore also not constituting a major burden for the participants. The number of times the questionnaires were administered were kept to minimum and discussed with the ethics committee prior to the permission to commence the study was given.

4.2.3 Outcome measures

Hamilton Depression Rating Interview (HAMD, Hamilton (1967))

The HAMD is the most commonly used semi-structured interview to measure the severity of depression in clinical trials (Bagby, 2004). The 17 items of the scale are rated on either 3- to 5-point scale with maximum 51 points and cut-off at 8 points. Internal reliability has found to range from 0.46 to 0.92 in 13 studies, with α>0.70 in 10 of the studies, retest reliability ranges from 0.81 to 0.98 in 4 studies, convergent validity is reported above 0.50 with most instruments measuring depression and is considered adequate (Bagby et al., 2004). The severity of depression is divided into three categories where a range for minor depression is 8 to 12 points, less than major 13 to 17 points and major more than 17 points (Bech, 1996). TK was instructed to use the HAMD by the psychiatrist who was involved in the recruiting and she had had training in diagnostics during her clinical psychology training.

Beck's Depression Inventory, Beck et al. (1961)

The BDI is a self-report questionnaire for measuring individual's present level of depression. It consists of 21 items scored on a 4-point scale addressing both psychological and somatic symptoms of depression. Mean internal reliability has been reported 0.86 and convergent validity with the HAMD 0.73 (Beck et al., 1988). The maximum score is 63 and widely used cut-off 10 points. Score between 10 and 18 points is considered to indicate mild depression, 19 to 29 points indicate moderate, and 30 to 63 points indicate severe depression.

Profile of Mood States, McNair et al. (1971)

The POMS is a 72-item self-report questionnaire to measure the present mood state using 5-point scales. The items are divided into 8 sub-scales: Anxiety, Depression, Anger, Vigour, Fatigue, Confusion, Friendliness, Elation, and average scores for each sub-scale are used. Additionally two more scores were calculated using the following formulas: Arousal = (Anxiety + Vigour) - (Fatigue + Confusion), Positive Mood = Elation - Depression.

The questionnaires and the interview scoring sheet are shown in Appendix C.1-C.8.

4.2.4 Procedure

Preparations

Assessment interviews were conducted during the week before the group sessions started. The participants read the study information sheet (see Appendices B.3 and B.4), the purpose and procedure of the experiment were explained, and subsequently they provided a written informed consent. The information sheet contained information also on planned ECG measurement and a control group activity as initially ECG measurements were planned as well as a control group with a different activity (audio-books and puzzle). The included information sheet version was approved by the ethics committee and was retained for this reason. The ECG measurements were not carried out due to technical problems and participants were informed of this change. Control group activity information was not removed for the same reason, even though due to recruiting difficulties control activity groups did not take place and the design was changed. Hence all the participants were informed that they were assigned to the music-making group.

Participation was voluntary and they were informed of their right to discontinue participation at any time without giving an explanation and that participation in the study would not affect their usual care. Hamilton Depression Rating interview was conducted by TK and the participant filled in Beck's Depression Inventory (BDI) and the Profile Of Mood States (POMS).

Intervention

Sessions lasted 45-60 minutes each and took place once a week for a 6-week period (see Figure 4.1 for an overview of sessions and measurements). A group of 2 or 3 participants sat in a room which was divided with screens so that the participants could hear but not see each other. Each participant sat in front of a music-therapeutical set-up comprising 5 instruments to play with (xylophone, drums, and percussion instruments). During the experimental session, participants were presented with a collection of predominantly instrumental cheerful musical pieces comprising classical music, Jazz, Samba, Irish and South-American folk music via a sound system (the list of music titles is appended to the chapter). The few pieces with lyrics were in languages the participants were not familiar with (e.g., roma). Participants were instructed to play along to the music with the instrument of their choice. This setup was chosen to minimize possible anxiety and discomfort musically untrained participants might experience having somebody watch them play an instrument. The same room arrangement was also used in (Koelsch et al., 2010) with healthy participants. The participants met before and after the sessions and could see each other during the sessions when they were moving around between different sets of musical instruments. The swap took place after every 2 pieces. They were introduced to each other at the first session and were able to talk to one another before and after the session, which might contribute to the effect as component of group interaction, yet, it is common practice for group activities in order to facilitate cooperation and as in active music therapy there is at least two individuals making music together, it increases the similarity to the natural music therapy situation.

The process and well-being of the participants were monitored by the experimenter during the session and the participants rated their feelings after each piece on three scales (pleasant unpleasant, calm lively, liking (from not at all to very much), Appendix C.4) using Self-Assessment-Manikins (Bradley and Lang, 1994). At the first session also familiarity of the musical pieces and memories related to the music were asked for, which was not repeated at the following sessions. They could also make a general statement about their current feelings before and about their experience after each session and comment on the music. As they were informed that their preferences play a role in the music selection for the following session, they usually emphasized the pieces they liked most or suggested those which could be replaced. In general one piece was replaced in the following session and the selection remained the same in the last 2 sessions as the liking ratings were consistently high.

After the session each participant got a CD with music and was instructed to listen to it once a day on the days between the sessions and rate their mood on a 5-point scale regarding 12 adjectives from the POMS questionnaire, which covered positive and negative aspects of mood (happy, cheerful, alert, relaxed, energetic, carefree, and sad, tense, unable to concentrate, hopeless, fatigued, anxious, respectively). The purpose of the CD was to familiarize the participants with the music, so that they would be more comfortable during the playing, and increase their exposure to the music. The mood ratings related to it allowed additional monitoring of their mood between the sessions and observing the effects of the same music when it is administered passively.

After the intervention period an appointment for the follow-up interview 1-2 weeks later was made where another HAMD was conducted and the participants once more rated their mood on the scales of BDI and POMS.

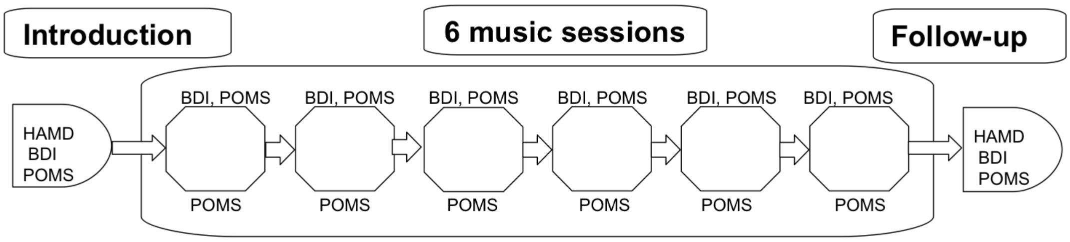

Figure 4.1: Intervention plan with measurements schedule. The questionnaires above the octagon were filled in before the session and the questionnaire below the octagon after the session.

4.2.5 Data analysis

Graphical representation and visual inspection was used for BDI, HAMD and POMS pre-session data, as this is the predominant form of analysis for case-series data. Sums were calculated for HAMD and BDI scales, and the 12-item mood rating. For POMS sub-scales averages were calculated.

4.2.6 Criteria for clinically significant change

Grundy et al. (1996) state that: *"The change that a patient experiences from pre- to post-treatment is evaluated to be clinically significant according to the following two standards: (1) crossing a cut-off point, and (2) change score greater than the Reliable Change Index (RCI)."* RCI of 7.74 points and a cut-off of 8 points was used for the 17-item HAMD scale, as suggested by Bech (1993). For BDI scores a shift of 10 points is considered a reliable change and a shift into the normal range (10 points or less as a sum of the scale) is considered a clinically significant change (Westbrook and Kirk, 2005).

4.3 Results

4.3.1 Music-making

The scores on BDI and HAMD before and after the intervention are shown on Figure 4.2 while Figure 4.3 presents the average change on POMS sub-scales and Figure 4.4 gives an overview of the dynamics of the between and in-session changes for each patient for POMS and BDI scores.

As shown on Figure 4.2, the changes of the HAMD scores indicate that 3 participants

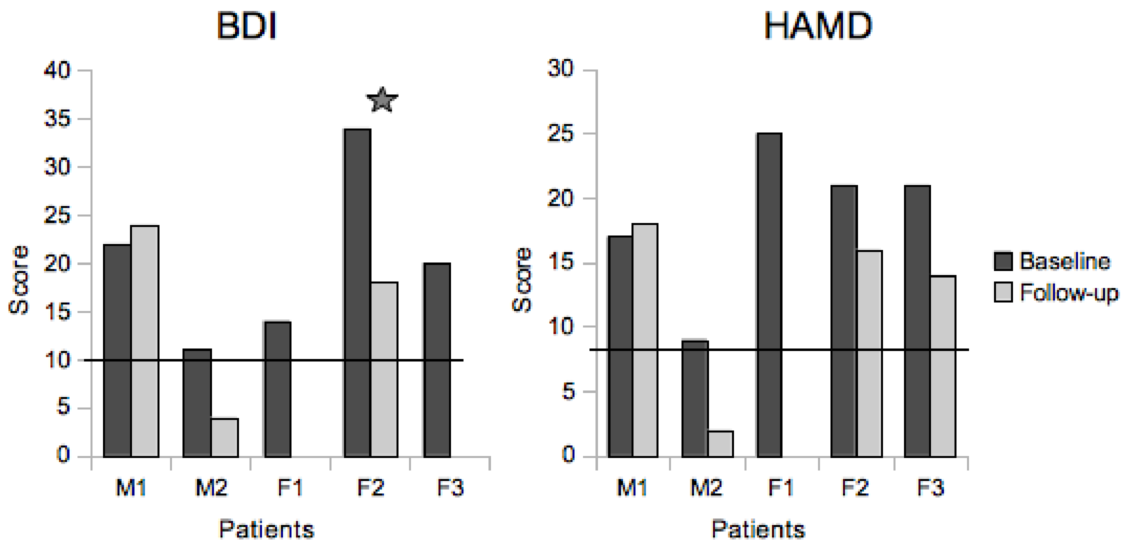

Figure 4.2: BDI and HAMD scores before and after the intervention period for all patients. Horizontal lines refer to cut-off points at 10 (BDI) and 8 (HAMD), * = reliable change. F1 was lost to follow up and F3 did not fill in BDI at follow-up.

moved to a milder range of depression (one from minor to norm and two from major to less than major) after the intervention. However, in all 3 cases the change is marginally smaller (7 points vs the RCI of 7.74) to consider it reliable. The change in BDI scores fulfills the criterion for reliable change for Participant 4 (difference of 16 points). The score of Participant 2 had decreased to the normal range, leaving the total change still too small to fill both criteria. This suggests that the evidence does not support the hypothesis that the intervention in the current dosage would reliably decreased the symptoms of depression.

The pattern of the average pre-post session mood change (Figure 4.3) is similar for all patients and demonstrates a replication of the effect. Anxiety, Depression and Fatigue decreased and Arousal and Positive Mood increased after the music-making session, which is in line with the effects found previously in healthy subjcts (Koelsch et al., 2010).

The dynamics of the mood by session (left panel) and within the session (right panel) can be seen on Figure 4.4. It can be observed that for Participant 1 the in-session chance shows the most consistent pattern with the largest amplitude while session to session dynamics shows improvement at the beginning which diminishes by the end of the intervention. He was also one of the two patients who received all sessions offered. Participant 2 shows also relatively consistent pattern with slightly smaller amplitude. By Participant

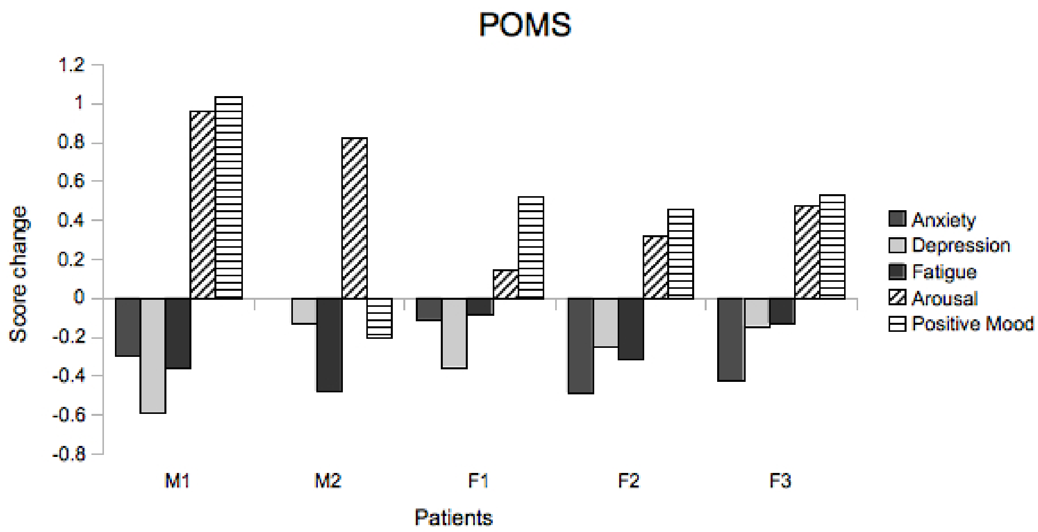

Figure 4.3: Average pre-post session change of POMS sub-scales' scores for all patients.

3 the in-session changes, while in the same direction with others, are in general the smallest, which might play a role in her decision to discontinue her participation. It is also worth noting that this patient had the highest baseline HAMD score. For Participants 4 and 5 the pattern is in the same direction but with a less consistent amplitude.

4.3.2 Listening to music

Participants 1, 2, 4 and 5 rated their mood on days between the music-making sessions using the 12-adjective scale described above both before and after listening to the next session music selection (Participant 3 did not return the diary sheets). The ratings were summed separately for positive and negative aspects of mood and the summary is shown in Table 4.1. Days with ratings only before or after listening were excluded (three for Participant 1 and one for each of the remaining three). The ratings for week 4 were missing for Participant 2 and 4, and for weeks 5 and 6 for Participant 5. The short rating scale was used instead of POMS to not burden the participants. Hence, the ratings allow evaluation of the dynamics over time (as shown on Figure 4.5) but not a direct comparison with the POMS scores from the music-making sessions.

Participants 1, 2, 4 rated their mood more positive after listening to music on majority of days. As shown it Table 4.1, ratings of the positive aspects of mood increased after the session whereas ratings of the negative aspects decreased. The median difference scores show consistent pattern. On a small number of days the change is also negative, however

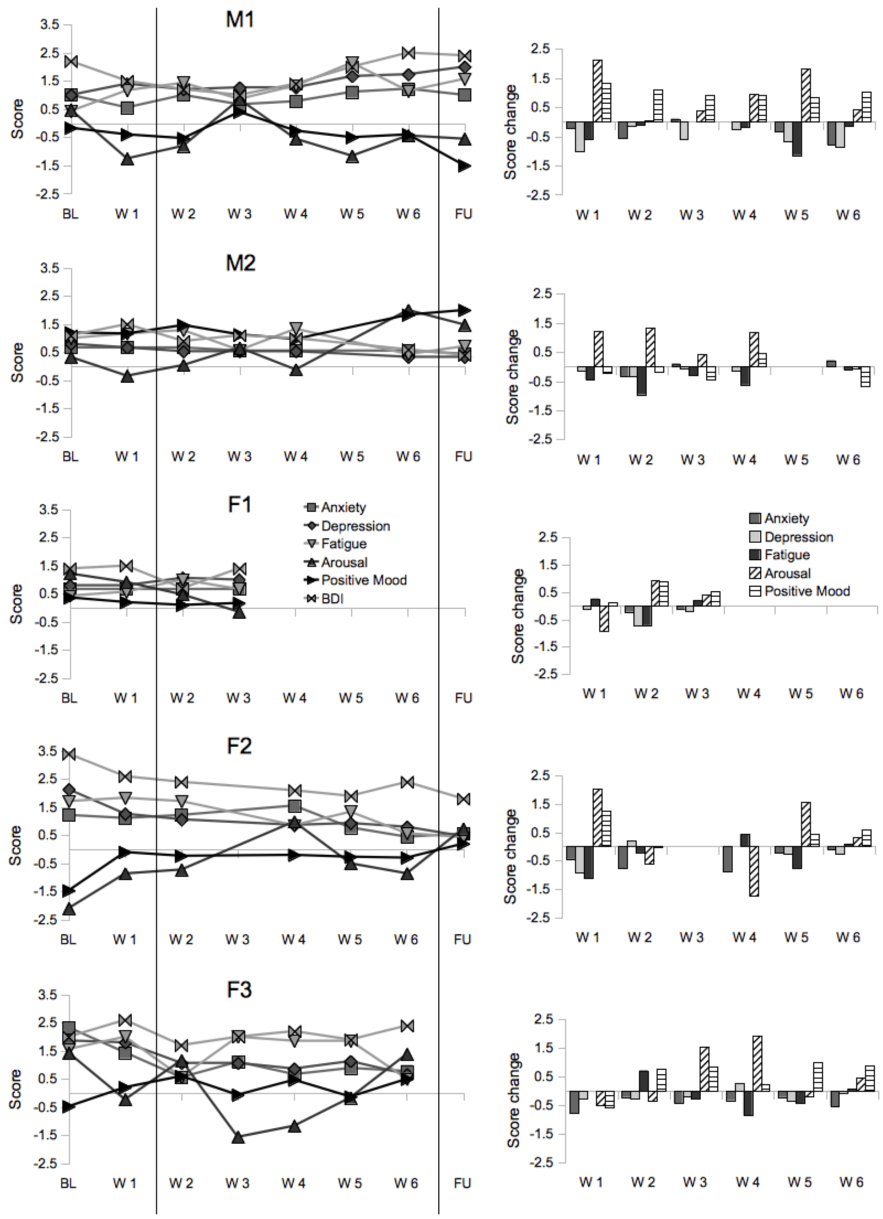

Figure 4.4: Pre-session scores on POMS sub-scales and BDI over the course of the intervention (left panel) and POMS sub-scale score changes during sessions (right panel) for all patients. Vertical lines separate baseline and follow-up measurements from the intervention period. BDI score is divided by 10. BL - baseline, FU - follow-up, W - week.

Table 4.1: *Changes in daily mood ratings before and after listening to the music.*

		Number of sessions		Median change	
		Positive	Negative	Positive	Negative
	N	(incr./decr.)	(incr./decr.)	(incr./decr.)	(incr./decr.)
Participant 1	33	27 / 6	10 / 19	3 / 0	0 / -1
Participant 2	29	27 / 1	0 / 21	5 / 0	0 / -2
Participant 4	30	23 / 5	3 / 25	2 / 0	0 / -2
Participant 5	23	8 / 10	3 / 13	0 / 0	0 / -1

Note: Positive and Negative - respective mood ratings; incr. = increase; decr. = decrease. N - number of days, when ratings were given. Number of sessions - number of listening sessions with increase or decrease of positive or negative aspects of mood. Median change - median difference between ratings before and after listening for both positive and negative aspects of mood.

both median decrease of positive and increase of negative aspects of mood remain zero. Participant 5 differs from the others and demonstrates less change in mood in response to the music listening, which is in line with relatively small amplitude changes observed in the music-making sessions.

Four of the participants gave feedback at the follow-up session and described the experience as pleasant and positive. Participant 1, whose depression symptoms has worsened due to acute stressful situation, revealed, that he would gladly continue attending the sessions if the study would continue as he perceived the mood change he experienced during the music-making as very helpful for coping with the situation he was in. He showed also the most visible behavioural change during the course of the intervention with more frequent expressions of positive emotions and active posture. Participant 2, who had played musical instruments before but quit due to depression, reported starting again and experiencing more of the pleasure it had provided before. Similar experience was reported by Participant 4. Participant 5 completed the follow-up HAMD interview, but not the additional measures or feedback beyond having liked participating at the music-making sessions. Participant 3 was lost at follow up, hence did not provide feedback.

4.4 Discussion

The aim of this study was to investigate whether weekly music-making sessions in a small group with minimal interference by the experimenter and without a strong verbal com-

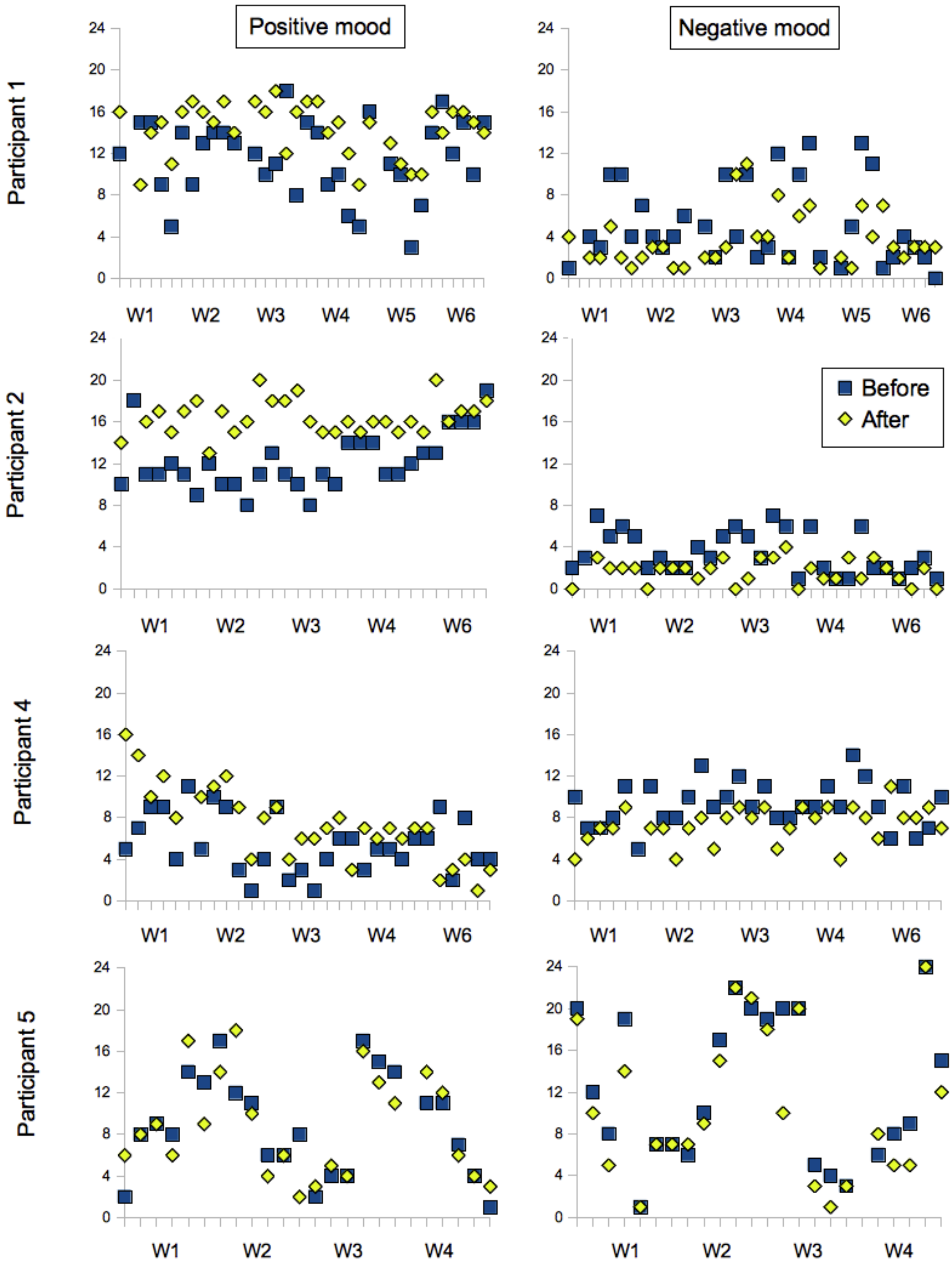

Figure 4.5: Positive and negative mood before and after daily music listening during the study period.

ponent alongside with passive daily listening to music would decrease the symptoms of depression and elevate the mood of patients suffering from depression. If this was the case, it would indicate, that music alone without additional therapeutic intervention has a beneficial impact on depression symptoms. Previous studies using self-administered music listening protocols to decrease depressive symptoms, have suggested beneficial effects, which last up to months after the intervention (e.g., Särkämö et al., 2008; Hsu and Lai, 2004).

Comparison of pre- and post-session mood as measured with POMS shows decrease in Depression, Anxiety, and Fatigue while Arousal and Positive mood have increased. A previous study by Koelsch et al. (2010) showed a similar outcome with healthy participants who only participated at one session of music-making. This suggests that music-making could be beneficial for depressed patients even without additional therapeutic intervention, at least in short term basis, to activate them and elevate their mood. Self-administered music listening also seemed to improve the mood of the participants as for majority of the days the post-session rating showed increase in positive aspects of mood and decrease in negative aspects, in line with previous findings (Chan et al., 2011).

In contrast, results of the clinical depression measures (BDI and HAMD) do not show a clear improvement pattern. While 3 out of 5 patients seem to improve over the course of the 6-weeks intervention period, the change is marginally smaller to reliably assign the effect to the intervention and clinically significant change was not recorded. It is possible, that increasing the number of sessions could have increased the effect, according to the recent meta-analysis by Gold et al. (2009), which demonstrated a dose-effect relationship for music-therapy and suggested 10 sessions to expect a medium size effect. The paper was published after the study had commenced, hence we could not consider this finding in the planning phase. Moreover, taken into account the variable length of depression history for the participants, it is likely that participants with longer history of depression could have needed a longer intervention to show an effect as the responsivity to treatment decreases with the increase of the number of episodes (e.g. Harro and Oreland, 1996). Alternatively, it could also be argued that in the previous music-therapy studies reporting decrease in depressive symptoms (e.g. Gold et al., 2009; Maratos et al., 2009), the reduction in the symptoms was related to the non-musical factors of the intervention or the increase of arousal due to increased physical activity, which has been shown to decrease depression symptoms (Cuijpers et al., 2006). Further studies could address these questions in order to disentangle the arousal and physical activity, and the musical-emotional aspects.

There are several limitations to this study to take into account, that may affect internal validity. First, all but one of the patients were taking antidepressive medication at the time of the study, which means that this concurrent treatment could also account for a part of the observed effect. We tried to overcome this problem by including patients for whom the drug treatment had started at least a month before they got involved in the study, to ensure that the primary medication effect had had time to emerge. This succeeded for all but one of the patients, who had started treatment three weeks prior to the study and stopped three weeks into the study.

Second concern is a short and unstable baseline with only two measurements for majority of the patients. This problem emerged as the study was conducted at a university and not in a clinical setting. We decided to keep the baseline period not much longer than a week to not to lose patients as it appeared that people who waited more than a week to start the intervention were more likely to drop out before the first session. It was not optimal, but in these circumstances unfortunately unavoidable.

Third limitation arises from the fact that the first author conducted both the clinical interviews and music-making sessions. Lack of blinding and involvement in the intervention could have brought about a bias in the second, post-intervention evaluation. To overcome this issue a partial blinding was undertaken – the interview scores were not calculated after the first interview and the data was not looked at until after the second interview 8 weeks later.

It can also be noted that case-series design, particularly A-B model, is vulnerable to external events, which can play a role in changing the observable pattern, and in the absence of other information A-B design gives only weak evidence for causal inference (Barker et al., 2002). For example, for Participant 1 a very stressful period started in the middle of the intervention which brought about a significant increase of the symptoms that was reflected in both BDI and HAMD scores. He reported at the follow-up interview the participation had helped him cope with the situation. The positive effect was clearly visible in POMS scores and he reported the largest pre-post session mood chance in a positive direction. Participant 2 medication had changed some weeks before the study commenced and therefore the improvement can not reliably be assigned to the intervention. His diagnosis was also relatively new, rising the question if the duration criterion had been fulfilled and whether a more appropriate diagnosis could have been an adjustment disorder with depressed mood. Not having access to the medical records and relying on patients' self-report is not ideal, however currently unavoidable due to data protection regulations.

Taken together, no consistent change was found on measures of depression suggesting that these measured mood effects may be short lived and do not appear to confer significant benefit over the course of treatment in terms of reductions in symptoms of depression. However, it can be concluded, that music-making in small groups and self-administered music listening have a positive short-term effect on mood for patients suffering from depression that is comparable with the effect it has on the mood of healthy individuals and this type of activity could help them to cope with the symptoms in their everyday life by lifting their mood and increasing motivation to engage in their dayly activities. In conclusion, the results suggest that music without other components of music therapy elevates mood, but does not reliably decrease the symptoms of depression. Using music-making and listening together enabled to increase the dose of the musical intervention, but does therefore not allow to differentiate the effect of music-making from the effect of listening, showing the cumulative effect instead. Further studies could address the questions, whether the improvement in mood was music-specific or whether it was due to increased arousal related to increased physical activity.

4.5 List of Stimuli

Composer	Title
Jonathan Richman	Egyptian Reggae
Ruben Gonzalez	Enriqueta
Ron Goodwin	Theme from Miss Marple
New Celtic Dimension	The Lucky Penny
Johann Sebastian Back	Badinerie (Ouvertüre No.2, BWV 1067)
The Gas Band	An Angel Went Up in Flames
Ruben Gonzalez	Fabiando
Georges Bizet	Prelude from Carmen
Louis Armstrong	St. Louis Blues
Giacomo Rossini	Ouverture to Wilhelm Tell
Paul Desmond	Take five
Native Peruvian music	Maria Lando
Native Peruvian music	Yo No Soy Jaqui

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KC contributed to the selection of data analysis method and interpretation of the results.

Chapter 5

Music-making with depression patients - Is the mood elevating effect specific to music?

Abstract

Music is widely used to elevate mood and a number of studies have shown positive effects of music on the mood of both healthy and somatically or mentally ill individuals. However, the evidence for the effectiveness of music in therapy of depression is scarce and it has remained unclear whether the observed beneficial effects are music-specific. To address this question we compared the effect of music-making sessions to a non-musical control activity, matched for auditory input and motor activity. Fifteen adult non-musician depression patients (1 male, median age 40 years) were divided into experimental and control groups and participated in up to 10 sessions during a period of 2 weeks. In the music-making group the patients played along with cheerful music presented via a stereo system, the control group listened to fairy tales and drew pictures. Hamilton Depression Rating Scale (HAMD) interview was conducted at the start and end of the intervention. Beck Depression Inventory (BDI) and Profile of Mood States (POMS) were used to monitor mood session by session. Symptoms of depression decreased in both groups, revealing no significant differences between groups. Hence, it can not be concluded, based on current evidence that the effect was music specific. However, comparison of pre-post intervention POMS scores shows a trend that music-making affects positively more aspects of mood than audio-book listening and therefore could be more beneficial, if only as a tool to improve mood temporarily, which would improve the patients' quality of life.

5.1 Introduction

Depression is one of the major health problems in the society and the leading cause of disability, affecting 121 million people worldwide and the prevalence is predicted to rise (WHO, 2010). Approximately 50% of people diagnosed with depression experience a recurrent episode and for circa 20% the disorder progresses to take a chronic course lasting 2 years or longer (Eaton et al., 2008; Spijker et al., 2002).

The symptoms of depression involve low mood, decreased energy and enjoyment, hopelessness, reduced interests and increased fatigue, along with disturbed sleep, appetite and other somatic problems (ICD-10, 2011). The variety of symptoms are suggested to be caused by imbalance of neurotransmitters (e.g. Harmer et al., 2009) or the immune system (e.g. Hestad et al., 2009), dysfunctional outcome of the stress response (Wager-Smith and Markou, 2011), and dysfunctional thought patterns that in context of stressful events lead to a negative perception of self and the world and manifest in depression (Beck, 1991).

Correlates of depression are also observable in the central nervous system. Structural changes in the brain have been reported, specifically decrease of hippocampal volume (e.g. Campbell et al., 2004), with a positive correlation between the extent of the atrophy and the number of depression episodes (McKinnon et al., 2009). This is supported by findings that with recurrent depression episodes the condition of the patient gradually declines with remission intervals growing shorter whereas responsivity to antidepressants and quality of life decrease, often leading to long-term disability (e.g. Harro and Oreland, 1996). This suggests that prolonged periods of depression create persistent changes in the brain that aggravate over time, making reaching a remission state increasingly difficult, and emphasizes the need for immediate and efficient interventions to avoid such negative long-term outcomes.

With a large proportion of the population suffering from depression, various therapies have been developed involving medication and psychotherapies. A combination of psychotherapeutic and pharmacological interventions is found to be more efficient in the majority of moderate and mild cases than each of the interventions alone (Stulz et al., 2010), perhaps because the combination addresses both the cognitive and physiological sides of the disorder. Yet, psychotherapies are expensive and not always available and antidepressants may show unpleasant side-effects that decrease treatment compliance (Bull et al., 2002). Moreover, antidepressants are found not to be sufficiently more effective than placebo in cases of mild to moderate depression (Kirsch et al., 2008) and according to a recent meta-analysis, the efficacy of psychotherapy has also been overestimated in previous meta-analyses due to inclusion of low quality studies that showed larger effect sizes (Cuijpers et al., 2010).

Hence, in the prospect of the increase of depression in the population, there is a need for treatments that would help decrease the suffering involved in having depression, but would also be less costly and have minimal side-effects. One of the potential alternatives could be music therapy, which is already widely used, but has so far little evidence to show its efficacy and specificity, even though in recent years the evidence base is growing (Gold et al., 2009; Maratos et al., 2009; Chan et al., 2011).

The studies to date that investigate the efficacy of music therapy and entertain a control group, have compared music-therapeutic intervention in all its complexity to treatment as usual (TAU) (e.g. Erkkilä et al., 2011), leaving open the question whether the observed effect was due to something specific to music therapy of just an effect of additional activity. It has also remained unclear whether music is the component of the therapy that carries the effect, as music therapy may involve various musical activities from listening to playing music in a group or composing music, therapeutic relationship between the patient and the therapist, and discussions and reflections on the music used (Maratos et al., 2009). This study contributed to answering the question of specificity by comparing the effect of music-making to an active control task on the symptoms of depression and mood of depression patients after 10 sessions of respective activity.

A specific effect of music could be expected because of its widely reported effects on emotions in general (for a review see Juslin and Västfjäll, 2008) and specific mood elevating effects resulting from music listening (e.g., Särkämö et al., 2008; Hsu and Lai, 2004; Chan et al., 2011) or music-making (Koelsch et al., 2010; Kreutz et al., 2004), particularly as one of the most noticeable facets of depression is low mood. Moreover, functional neuroimaging studies have shown in response to music activation in brain structures involved in pleasure and reward (Blood and Zatorre, 2001), but also emotion processing in general (e.g. Koelsch, 2010), including among others hippocampus, which is affected by depression (Campbell et al., 2004; McKinnon et al., 2009) and where antidepressants have been shown to reverse the decrease in volume (e.g., Wager-Smith and Markou, 2011). Hence activities that increase activation in the affected areas could potentially be beneficial in decreasing some of the symptoms of depression.

The frequency with which musical activities are offered as a part of musical intervention and also the length of the intervention varies on a large scale from one single session to several months of regular sessions. A recently published meta-analysis by Gold et al.

(2009) on music therapy with patients with serious mental disorders also included the analysis of dose-effect relationship. They showed that a medium size effect on depression symptoms can be expected after ten sessions.

Passive music therapy sessions take usually place daily (e.g. Hanser, 1994; Särkämö et al., 2008), as patients are often independent in conducting them or need only limited assistance. The usual frequency for active music therapy sessions is 1-2 times per week (Erkkilä et al., 2008, 2011; Aldridge et al., 2005), but different schedules have not been directly compared and therefore it is unclear whether this is the optimal frequency or whether more frequent sessions would yield a different effect. The patients in the study by Chen (2009) participated in daily active music therapy sessions during an eight week period and the members of the experimental group showed signs of improvement after one week, which gives grounds to expect that a moderate increase in the frequency of sessions could result in a more rapid improvement. Considering these findings (Gold et al., 2009; Chen, 2009) we decided to conduct 10 daily session within a two weeks period. This schedule would, taking into account the dose-effect relationship, allow us to expect a medium size effect on the symptoms of depression, but would not represent a big additional burden for the patients or exceed the time constraints of the study.

In selecting the music for the music-making group, the condition of the participants needs to be considered, as depression affects musical preferences. Specifically, patients suffering from depression were found not to like highly energetic music (Punkanen et al., 2011) and have a general negative bias towards emotional stimuli (e.g. Naranjo et al., 2011), which may play a role in their ability to appreciate music. Therefore, even though the selection of musical stimuli consisted of cheerful music, that elevated mood in healthy individuals in a previous study (Koelsch et al., 2010) and hence could be expected to have a mood elevating effect on depressed patients as well, we took the musical preferences of the patients into account while compiling the music selection for each session to not expose them to music they do not like as this might evoke negative emotions instead.

The aim of this study was to investigate whether music-making alone without the other components of music therapy would reduce the symptoms of depression and elevate mood in patients suffering from depression. To test whether the potential effect would be music-specific or a similar non-music activity would carry a similar effect, we chose to have a audio-book listening and picture drawing task as an active control intervention instead of a waiting list or treatment as usual control group. That is, the control activity also had auditory, sensory-motor, attentional and social component comparable to the music-making. In light of previous research on the effects of music on mood and the evidence available from music therapy research we expected the music-making to decrease the symptoms of depression more than the control activity and the mood to improve more in the music-making group in terms of decreased anxiety, depression, and fatigue and an increase in arousal and positive mood.

The study was approved by the Ethics Review Committee on Human Research of the University of Tartu at 20.04.2009., registration number: 181/T-15 (see Appendix A.4.) and the Ethics Review Committee did not request any changes in the protocol after the application was submitted and prior to granting the permission to commence the study.

5.2 Method

5.2.1 Participants

Patients were recruited by spreading the information among the psychiatrists and psychologists working at the hospitals where the study was conducted, GP surgeries in the neighbourhood, and via adverts in the local newspaper. All involved clinicians were informed about the inclusion (diagnosed mild to moderate depression) and exclusion criteria (other psychiatric diagnoses, neurological, immunological problems, recent/present viral infection, substance abuse) and asked to conduct the pre-selection and inform eligible patients about the study. Patients were asked to contact the researchers via phone or e-mail if they were interested in participating. When they did, additional information was given regarding the study and an appointment was made for the introductory interview. For patients who contacted the experimenters directly without a referral from their doctor, the decision about inclusion was made after the introductory interview was conducted. Participants were informed that taking part in the study does not affect their usual care.

A total of 19 patients participated in at least 3 intervention sessions (1 male, 18 female). Additional 6 patients participated in only 1-2 sessions (3 in both conditions) and were excluded from the presented data analysis. Of the 19 patients, 15 completed the respective intervention sessions and the follow-up measurements and were included in the analysis (8 in the music group and 7 in the control group).

The reasons for drop-out varied between patients, being mostly unrelated to the nature of the intervention. One person had unexpected difficulties with their baby-sitting arrangements, one's work schedule changed making it inconvenient to come to the hospital for the session time. One who dropped out after the first week disclosed that they are feeling much better and would continue music-making at home, like they had done in the past but discontinued after falling ill with depression. One person did not like the music as it differed from their usual preference and decided to discontinue participation after the first session. For three participants who lived further away, it turned out to be difficult to attend the sessions in one of the hospitals that was located outside the neighbouring town, because of the infrequent and not matching public transport schedule and they informed the experimenter about their decision not to continue for that reason. One patient discontinued for physical health problems and one did not give feedback in that matter. One participant from the music group was lost at the follow-up interview after the intervention despite attending all sessions. One participant from the control group forgot to fill in the BDI at the follow-up interview and one missed the POMS. One session was missed by some of the patients for physical health, child care or work reasons and they informed the experimenter beforehand either by phone or at the previous session.

In the music-making group the median age was 36.5 years (range 20 - 52 years). The length of depression history ranged from 1.5 months to 15 years (median 3 years) with 1 to 10 depression episodes (median 2.5) within this period. Three of the eight patients in this group were taking antidepressants at the time of the study for 3 - 120 months prior to the start of the study. In the control group the median age was 40 years (range 23 - 49 years). The length of depression history ranged from 6 months to 11 years (median 4 years) with 1 to 5 depression episodes (median 3) within this period. Three of the seven patients in this group were taking antidepressants at the time of the study for a period of 1 - 2 months prior to the start of the study.

Based on HAMD ratings, one person in both groups was currently having major depressive episode, two participants in the music group and three in the control group fell into the category "less than major", two participants from both groups had minor depression. Three patients in the music group and 1 in the control group were currently in remission at the start of the intervention, scoring below 8 points. BDI indicated minimally mild depression in all cases.

The age difference between groups was not significant ($p = .21$).

5.2.2 Stimuli

Cheerful instrumental musical pieces comprising classical music, Jazz, Samba, Irish and South-American folk music accompanied the music-making task in the experimental group. The same pieces had been used by Koelsch et al. (2010) and were rated as happy and pleasant by healthy individuals. Non-violent pleasant fairy tales were selected from a selection of estonian audio-books to accompany the drawing task. A list comprising the titles of the musical pieces and the fairy tales is provided in the Appendix.

5.2.3 Outcome measures

Hamilton Depression Rating Interview (HAMD; Hamilton, 1967)

The HAMD is, despite various critiques, the commonly used semi-structured interview to measure the severity of depression in clinical trials (Bagby, 2004). The 17 items of the scale mark different symptoms of depression (e.g. depressed mood, retardation, etc.) and are rated on either 3- to 5-point scale (from "absent" to "severe") with maximum 51 points and cut-off at 8 points (e.g. Bech, 1996). Internal reliability has found to range from 0.46 to 0.92 in 13 studies, with α>0.70 in 10 of the studies, retest reliability ranges from 0.81 to 0.98 in 4 studies, convergent validity is reported above 0.50 with most instruments measuring depression and is considered adequate (Bagby et al., 2004). The severity of depression is divided into three categories: the range for minor depression is 8 to 12 points, less than major 13 to 17 points and major more than 17 points (Bech, 1996).

Beck's Depression Inventory, (BDI; Beck et al., 1961)

The BDI is a self-report questionnaire for measuring individual's current level of depression. It consists of 21 items scored on a 4-point scale, where the symptoms are described with increasing severity, addressing both psychological and somatic symptoms of depression (e.g. 0 = i do not feel sad; 1 = i feel sad; etc.). Mean internal reliability has been reported 0.86 and convergent validity with the HAMD 0.73 (Beck et al., 1988). The maximum score is 63 and widely used cut-off 10 points. Scores between 10 and 18 points are considered to indicate mild depression, 19 to 29 points indicate moderate, and 30 to 63 points indicate severe depression.

Profile of Mood States, (POMS; McNair et al., 1971)

The POMS is a 72-item self-report questionnaire to measure the current mood state using a list of adjectives that are evaluated on a 5-point scales (e.g. Refreshed; 0 = not at all; 4 = extremely). The items are divided into 8 sub-scales: Anxiety, Depression, Anger, Vigour, Fatigue, Confusion, Friendliness, Elation, and average scores for each sub-scale are used. Additionally two more scores were calculated using the following formulas: Arousal = (Anxiety + Vigour) - (Fatigue + Confusion), Positive Mood = Elation - Depression.

The questionnaires were completed in Estonian. For all but the Profile of Mood States a validated translation existed, as both BDI and HAMD are commonly in clinical use. Profile of Mood States was translated for this study by the author and translated back by a professional translator who also completed the final comparison.

The questionnaires and the interview scoring sheet are shown in Appendix C.

5.2.4 Preparations

Assessment interviews were conducted during the week before the group sessions started. The purpose and procedure of the experiment were explained to the participant (see Appendices B.5. and B.6. for the study information sheet) and they signed informed consent form. Participation was voluntary and they were informed of their right to discontinue participation at any time without giving an explanation. Questionnaire about background and depression history (General information questionnaire, Appendix C.5.) and Hamilton Depression Rating interview were conducted by a psychologist (in the first study site) or psychiatrist (in the second) not involved in other parts of the study and the participant was asked to fill in Beck's Depression Inventory (BDI) and the Profile Of Mood States (POMS). The results were not disclosed to the person responsible for dividing people into the groups according to their availabilities and assigning the activities to the groups. The latter was decided based on a coin toss.

5.2.5 Procedure

Sessions lasted 45-60 minutes each (including filling in the questionnaires POMS every day before and after the session and BDI before the session on every second day, see Figure 5.1 for a flow chart), and took place every morning on working days for two weeks. Written instructions were provided before each session (at the first session, the participants were prompted to read the instructions and at the following sessions the instructions were available on the desks for the case the participants wanted to reread them) and before the first music session a short introduction was given about how to use the instruments.

Experimental group: A group of 3-4 participants sat in a room, which was divided with screens so that the participants can hear but not see each other. The screens were used to decrease the possible discomfort and anxiety musically untrained participants might experience when somebody would watch them play a musical instrument. The same procedure was followed in (Koelsch et al., 2010) study with healthy participants. The participants met before and after the sessions and could see each other during the sessions

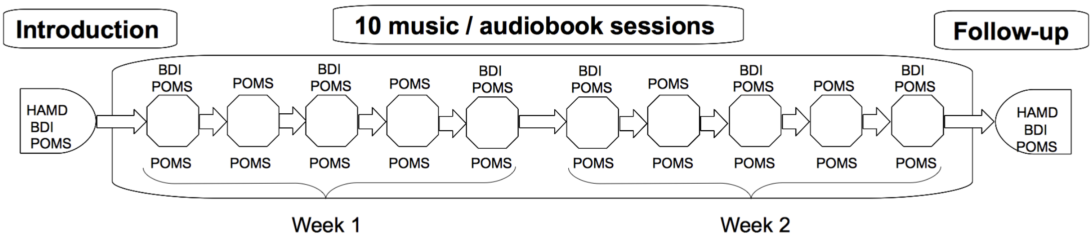

Figure 5.1: Intervention plan with the measurements schedule. The questionnaires above the octagon were filled in before the session and the questionnaire below the octagon was filled in after the session.

when they were moving around between different sets of musical instruments. The swap took place after every 2 pieces. They were introduced to each other at the first session and were able to talk to one another before and after the session.

Each participant sat in front of a music-therapeutical setup consisting of 5 instruments to play with (xylophone, several drums, and percussion instruments). During the experimental session, participants were presented with a collection of predominantly instrumental cheerful musical pieces via a sound system. Only one piece of music was played at a time and the few pieces with lyrics were in languages the participants were not familiar with. Participants were instructed to play along to the music with their instruments and not to talk to each other during the music-making. After each piece of music they were asked to give a liking rating to the piece and rate how pleasant and lively they felt during this piece of music, using the valence and arousal scales of the Self-Assessment-Manikins (Bradley and Lang, 1994). The participants were informed that their preferences play a role in the music selection for the following session and they used the opportunity to emphasized the pieces they liked most or suggested the ones that could be replaced. In general one piece was replaced in the following session and the selection remained the same in the last 2 sessions as the liking ratings were consistently high.

Control group: A group of 3-4 participants was instructed to listen to fairy tales in the form of an audio-book to control for acoustic input and draw something related to what they hear to control for sensorimotor activity, involvement and attention. The room setting was the same as for the experimental group.

After the two weeks intervention period an appointment for the follow-up interview was made for 1-2 weeks later, where another HAMD was conducted by the same psychologist or psychiatrist who gave the first rating and the participants were once more asked to rate their mood on the scales of BDI and POMS.

5.2.6 Data analysis

The Beck Depression Inventory and the Hamilton Depression Rating Scale provide ordinal scale data, but sums were calculated as conventional. To compare the pre-post intervention scores on these scales, Friedman's one-way ANOVA for repeated measures was computed for both groups separately. To test the differences between groups, Mann - Whitney U was computed for BDI and HAMD scores before and after the intervention separately given the lack of appropriate non-parametric analogue for two-way ANOVA that would accommodate the small number of subjects and provide information about interactions. Even though sums were calculated implying that the data were treated as being on the interval scale, they did not fulfill the prerequisites for parametric analysis (distribution, for example) and therefore non-parametric tests were considered appropriate.

The same rationale applies for the Profile of Mood States, for which average scores for the sub-scales were calculated. Mann - Whitney U-s were computed for between groups comparisons of the before and after the intervention scores on the sub-scales Anxiety, Depression, Fatigue, Arousal, and Positive mood and Friedman's test for comparisons of inside group pre-post intervention scores on the same scales.

5.3 Results

Comparison of the scores of the depression measures BDI and HAMD before and after the intervention showed that the symptoms decreased in both groups (see Table 5.1 and Figure 5.2). Between groups analysis showed no significant difference between groups before (BDI before: $U = 19.5$, $p = .32$; HAMD before: $U = 16.0$, $p = .16$) and after the intervention (BDI after: $U = 24.5$, $p = .69$; HAMD after: $U = 24.0$, $p = .64$). This indicates that the groups did not differ in the severity of depression before the intervention and suggests that the symptoms of depression in one group did not decrease significantly more than in the other group.

When considering change in depression symptoms for single patients, according to the post-intervention HAMD scores, depression symptoms of three participants in the music group had decreased to the level of minor depression and five were in remission. In the control group one participant could be described as having less than major depression, one as minor depression, and five were in remission. Two participants in the music group and

Table 5.1: *Inside groups comparisons of the BDI and HAMD scores before and after the intervention for both groups.*

Group	Measure	MR Intro	MR Follow-up	χ^2	p	N
Music	BDI	2.00	1.00	8.0	.005	8
	HAMD	1.94	1.06	7.0	.008	8
Audiobook	BDI	1.93	1.07	6.0	.014	7
	HAMD	1.86	1.14	3.6	.059	7

Note: MR = Mean rank.

four in the control group had improved sufficiently to fill the criterion of reliable change (Reliable Change Index, 7.74 points for HAMD, Bech, 1993). However, three patients in the music group and one in the control group were in remission, that is, presented only a limited number of symptoms, already at the start of the intervention, which limited the space for improvement in those cases.

While comparing the pre-post intervention scores on POMS sub-scales between groups did not reveal significant differences, inside-group comparisons suggest differential effects of the different activities. In the music-making group anxiety, depression and fatigue decreased, positive mood increase and there is a trend for an increase in arousal. In the audio-book group only fatigue decreased significantly and there is a trend for a decrease in depression whereas the remaining aspects of mood remained largely unchanged (Table 5.2 and Figure 5.3).

5.4 Discussion

The aim of this study was to investigate whether music-making, in absence of the other aspects of music therapy, would improve the mood and reduce depressive symptoms in people diagnosed with depression. In addition, we used listening to audiobooks and drawing as a non-musical active control condition, matched for auditory input and motor activity, to investigate whether the effect was music-specific or whether a similar non-musical activity would carry a similar effect.

The results show that the symptoms of depression did not decrease significantly more among the patients in the music-making group in comparison to patients in the control group, even though the condition improved for patients in both groups. This suggests that one intervention was not significantly better in reducing depression and supports the

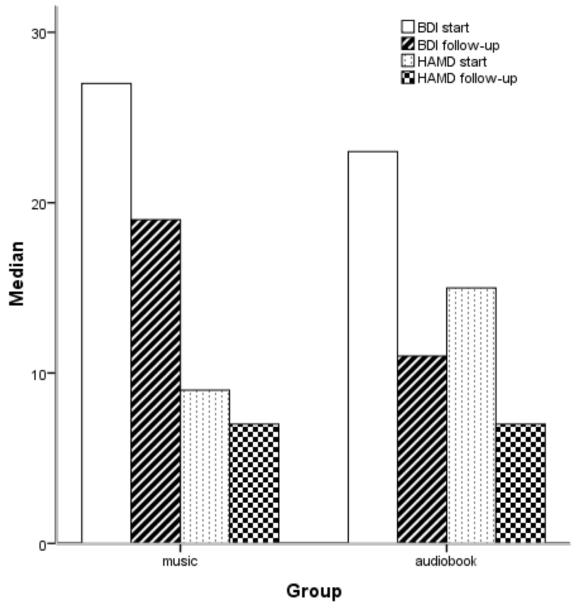

Figure 5.2: Median pre-post intervention scores on the BDI and HAMD scales. N(music) = 8 and N(audiobook) = 7.

Table 5.2: *Inside groups comparisons of the POMS sub-scales' scores before and after the intervention for both groups.*

Group	Measure	MR Intro	MR Follow-up	χ^2	p
Music (N = 8)	Anxiety	1.94	1.06	7.0	.008
	Depression	2.00	1.00	8.0	.005
	Fatigue	2.00	1.00	8.0	.005
	Arousal	1.13	1.88	4.5	.034
	Positive mood	1.00	2.00	8.0	.005
Audiobook (N = 7)	Anxiety	1.57	1.43	0.2	.655
	Depression	1.86	1.14	3.6	.059
	Fatigue	1.93	1.07	6.0	.014
	Arousal	1.29	1.71	1.3	.257
	Positive mood	1.43	1.57	0.1	.705

Note: MR = Mean rank.

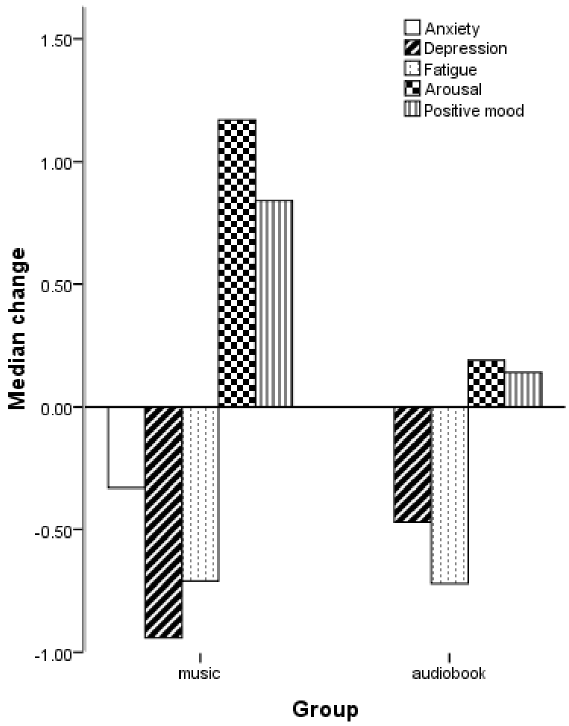

Figure 5.3: Median pre-post intervention change on POMS sub-scales. N (music) = 8, N(audiobook) = 7.

hypothesis that the effect is not music-specific and might be due to the additional activity in the daily schedule of the patients or some other factor.

However, the comparison of the general mood before and after the intervention suggests that music-making may have some advantages over audio-book listening as anxiety, depression, and fatigue had decreased and positive mood had increased significantly in the music-making group after the intervention (as observable on Figure 5.3) whereas in the audio-book group only the decrease in fatigue reached significance. Therefore, even though based on the current data, one activity was not significantly better in reducing depression symptoms, for patients who suffer from depression, also a temporarily improved mood is valuable and in this respect music-making seems to be affecting more aspects of mood, and may therefore have an advantage. Perhaps a parallel could be drawn with antidepressant medication, which also contributes to reduction of somatic symptoms, increasing the levels of energy and motivation and improving mood, so that the patient would be more able to address the dysfunctional cognitive patterns related to the disorder and therefore medication together with cognitive-behavioural therapy has found to be more effective than either of the interventions alone (Stulz et al., 2010). Future studies could address the question whether music-making together with a cognitive therapy component would be more effective and might lead to a decrease in use of medication.

There are limitations to this study that need to be considered. First, the patient group was relatively small and heterogenous in terms of depression severity, number of episodes and duration of depression, which may have had an impact on the results. Patients with longer depression history are found to be less susceptible to treatments (e.g. Harro and Oreland, 1996) and might have needed a larger number of intervention sessions to show an effect therefore influencing the general group outcome. Moreover, three patients in the music group and one in the control group were in remission, that is, presented only a limited number of symptoms already at the start of the in- tervention, which limited the space for improvement in those cases and suggests a possible floor effect. The small sample size did not allow testing the sub-groups separately. In the future, comparison of groups with recent diagnosis and chronic course of the disorder could contribute to a better understanding in the differences in the dynamics of the improvement and might be worth investigating. The issue of drop-outs poses also a problem for generalizability as even though they usually did so for reasons not directly related to the intervention, it still shows some selection bias in the sample as, for example, people with either means or ability to plan and organize transportation to the study site or more flexible work arrangements are included while others in different circumstances were not.

It could also be argued, that the drawing task was less active than music-making task, hence evoking higher level of arousal, however, moving a shaker, for example, does not necessarily involve more physical activity than drawing and all other aspects of the task were as similar as possible, making it rather unlikely that this difference in the task would change the effect significantly. Yet, adding physiological measures to monitor arousal and physical activity – heart rate or electrodermal activity, for example – could clarify this aspect in future studies. Particularly as physical activity has been found to decrease depressive symptoms (Cuijpers et al., 2006) and could be one of the non-specific factors contributing to the improvement related to music therapy.

Depression is a complex disorder comprising a number of physiological and cognitive mechanisms that play a role in maintaining the variety of somatic and psychological symptoms. Even though current data does not allow a conclusion that one of the interventions used was more effective in reducing the symptoms of depression, it appears that music-making brings about more positive changes in mood, perhaps contributing to the motivation and energy that is needed for a better functioning in the everyday life of the patient. An additional cognitive therapy component in the treatment could use this increased potential for change, to address the dysfunctional cognitive patterns that maintain the depression to evoke a lasting improvement. Music-making might therefore be more beneficial than listening to audio-books to facilitate this, but the heterogeneity and the size of the sample limit the generalizability and the result requires a replication.

5.5 List of Stimuli

Music	
Author	Title
Jonathan Richman	Egyptian Reggae
Ruben Gonzalez	Enriqueta
Ron Goodwin	Theme from Miss Marple
New Celtic Dimension	The Lucky Penny
Johann Sebastian Bach	Badinerie (Ouvertüre No.2, BWV 1067)
The Gas Band	An Angel Went Up in Flames
Ruben Gonzalez	Fabiando
Georges Bizet	Prelude from Carmen
Louis Armstrong	St. Louis Blues
Giacomo Rossini	Ouverture to Wilhelm Tell
Paul Desmond	Take five
Native Peruvian music	Maria Lando
Native Peruvian music	Yo No Soy Jaqui
Parno Graszt	Ravagok a zongorara
Audiobooks	
Author	Title
Edgar Valter	Pokuraamat (The book of Pokus)
Astrid Lindgren	Vahtramäe Emil (Emil of Lönneberga)
Andrus Kivirähk	Lotte resi lõunamaale (Lotte's trip to the south)

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MK and TE were involved in recruiting patients for the study and conducting the HAMD clinical depression interviews before and after the intervention.

Chapter 6

The role of personality in music-evoked mood change.

Abstract

Music is widely used for emotion induction, yet, individual differences like personality is often not considered as a possible moderator. Personality factors affect musical preferences and impact cognitive performance in presence of music, but might also affect how people are emotionally influenced by music. The current aim is to investigate how personality moderates the emotion-inducing effects of music. The results would contribute to improved understanding of the role of individual differences in emotion induction and better tayloring of music-related therapies. To address this question, one music-making session was conducted with 108 healthy students (52% with musical training), who had previously filled in a personality questionnaire. The participants used simple instruments to play along with cheerful recorded music. Self-reported mood was recorded before and after the music-making session. Results showed overall decrease in Depression, Anxiety and Fatigue after music-making whereas arousal and Positive mood increased, more pronouncedly especially in the group with musical training. Moderating effects of personality on the mood change were found, specifically, Introversion was related to a decrease in Depression and Anxiety and increase in Positive mood, Agreeableness to a decrease in Fatigue, whereas Openness to Experience predicted increase in Fatigue and decrease in Arousal.

6.1 Introduction

It is well established that music can be used to modify mood (e.g., Juslin and Västfjäll, 2008). It is also assumed that there is some universal effect of music on emotions - in the emotion induction studies cheerful music is used to induce joy and sad music to induce sadness (e.g., Bouhuys et al., 1995; Mitterschiffthaler et al., 2007). The music is expected to make the participants feel either cheerful or sad, respectively, but perhaps not exactly the same way – all pieces do not have the exactly same effect on all individuals, as could be concluded from the fact that the "subjects were selected who showed substantial differences in the depression scores between the depressed and elated [mood induction] condition" (Bouhuys et al., 1995, p. 219), indicating that some subjects were less susceptible to the mood induction by the musical pieces the experimenters used. These individuals could potentially be affected more by a different selection of music or are perhaps in general affected by music in a different way or to different extent. In this study we investigated the latter aspect, addressing the question, whether differences in personality traits could explain differences in mood change brought about by participating in music-making.

Personality is likely to be involved in moderating emotional reactions because it is considered to be a relatively stable set of traits, characterizing a person and playing a role in how the person relates to the world and other people around them. Personality is in contemporary approaches described in terms of a finite collection of largely-independent traits, that fall in a small number of factors (Digman, 1990). The most common model contains five factors: Extraversion – Introversion, which refers to the needed amount of external stimulation and engagement with the external world; Neuroticism – Emotional stability, which describes the degree of emotional reactivity and proneness to negative emotions (Eysenck, 1970); Agreeableness, which describes the degree of concern about social harmony and cooperation; Conscientiousness, which involves self-control, goal-orientedness, and self-efficacy; and Openness to Experience, which includes traits like creativity, curiosity, openness to new ideas, flexibility, adventurousness and liberalism (Digman, 1990).

To date there is rather little literature on emotion induction with music that would take into account also individual differences. A few studies have investigated the experience of "chills" (e.g., McCrae, 2007) or autonomic activation (Kallinen and Ravaja, 2004) in light of personality differences. Links have been found between Openness to Experience and the experience of "chills" in the context of aesthetic stimuli (McCrae, 2007) and as "chills" are highly pleasurable experiences activating brain areas implicated in reward and emotion (Blood and Zatorre, 2001), it could be expected that people who are more likely to experience chills in response to music would be also emotionally more affected by music.

Kallinen and Ravaja (2004) showed increase in self-reported arousal among people scoring low in Sociability (a sub-scale of Extraversion), that is, the level of arousal increased among less sociable individuals. Moreover, increased positive activation was observed particularly among people with high Neuroticism and Anxiety scores after a session of listening to music which suggests that people prone to be anxious, worried, and introverted (or at least not particularly sociable) could profit the most from music-related activities.

In contrast, the "disturbing" effect of music on performance in cognitive tasks differing on the dimension Extraversion-Introversion has been investigated more (Cassidy and Macdonald, 2007; Furnham and Bradley, 1997; Furnham and Strbac, 2002; Furnham and Stephenson, 2007), perhaps because of its importance for optimal learning environment arrangements. It was found, that background music impaired introverts' performance in a reading comprehension test more compared to extraverts (Furnham and Bradley, 1997; Furnham and Strbac, 2002), demonstrating that introverts are more distracted by musical stimuli. This seems to be in line with the finding by Kallinen and Ravaja (2004), regarding introverted people being potentially more influenced by music, as they seem to involuntarily attend to musical stimuli even when instructed to perform a different task.

In research on musical preferences, personality differences play an important role, both in respect to preferred musical styles and the use of music (e.g., Chamorro-Premuzic and Furnham, 2007; Juslin and Laukka, 2010; Rentfrow et al., 2011; Rentfrow and Gosling, 2003; Delsing et al., 2008). Rentfrow and Gosling (2003) report undergraduate students' liking of jazz, classical or folk music to be positively related to Openness to Experience while liking country or pop music, for example, was positively related to Extraversion, Agreeableness and Conscientiousness and negatively to Openness to Experience. Chamorro and colleagues (2010) have suggested that the preferred styles also reflect the reason why people listen to music - individuals scoring high on Neuroticism predominantly use music for emotional regulation and were found to have a preference for sad music, whereas Extraverts prefer cheerful music and like to have music on the background for different activities, perhaps to up-regulate the low arousal level. High score on the Openness to Experience scale suggests predominantly cognitive use of music, that is, these individuals appreciate novel and complex music that gives them intellectual pleasure. Cognitive use of music is characteristic also of individuals scoring high on the Conscientiousness (Chamorro-Premuzic et al., 2010).

Along with preference, familiarity with the music could also affect the pleasantness of the musical experience and therefore influence the mood elevating effect. Repeated exposure, which increases familiarity, has been found to have a polarizing effect on the liking ratings - repeated listening to positive arousing music increased the liking whereas for negative arousing music the liking ratings decreased with repetition (Witvliet and Vrana, 2007; Fung, 1996).

In both mood induction and musical preferences studies referred to above, the focus has been on music listening. Of the few studies looking at mood induction using music-making (Koelsch et al., 2010; Kreutz et al., 2004) none has considered personality to account for the differences in the effect. Looking into the variations in the mood change in light of personality differences would contribute to better understanding of how individual differences modulate the mood induction effects of music.

The aim of this study was to investigate whether personality traits moderated the effects of cheerful music on participants' self-reported mood. Based on previous findings it was hypothesized that individuals scoring high on Neuroticism, who naturally prefer to use music for emotional regulation, would be more susceptible to the mood elevating effects of music (Chamorro-Premuzic et al., 2010). An effect of Extraversion was also expected, as people scoring low on Extraversion (or in other words high on Introversion) are found to be more affected by music (e.g., Furnham and Strbac, 2002). In addition, the effect of musical training was explored.

6.2 Method

6.2.1 Participants

The participants (108 healthy students, 36 male and 72 female, mean age 20.8 $\pm$ 3.5 years) were recruited from the School of Psychology subject pool and remunerated for their participation either with respective amount of course credits, if they were psychology students, or 5 pounds per hour. Approximately half of the sample (52 %) had had some musical training (range 0.5 - 15 years, median 4 years).

The study was approved by the University of Sussex Ethics Committee (see Appendix A.5. for approval letter).

6.2.2 Stimuli

A selection of cheerful predominantly instrumental musical pieces consisting of classical music, jazz, and various folk music accompanied the music-making task. The same pieces had been used by Koelsch et al. (2010) and were rated as happy and pleasant. A list of the titles of the musical pieces is provided in the Appendix.

6.2.3 Materials

International Personality Item Pool (IPIP-NEO Facets; Goldberg et al., 2006)

IPIP-NEO Facets Likert-type questionnaire consists of 300 items, which are divided into 5 factors, each comprising 6 sub-scales, which contain 10 items. The factors are Neuroticism, Extraversion, Openness to Experience, Agreeableness, and Conscientiousness. The average internal reliability index $\alpha = .80$. All items are rated on a 5-point scale ranging from 1 = "very inaccurate" to 5 = "very accurate". All 300 items were used.

Profile of Mood States, (POMS; McNair et al., 1971)

The POMS is a 72-item Likert-type self-report questionnaire to measure the current mood state using 5-point scales (e.g., Lively - 0 = "not at all", 4 = "extremely"). The items are divided into 8 sub-scales: Anxiety, Depression, Anger, Vigour, Fatigue, Confusion, Friendliness, Elation.

6.2.4 Procedure

Before starting the experiment, the procedure was explained, participants read the study information sheet (Appendix B.7) and had a chance to ask questions before signing an informed consent form. They were reminded that participation was voluntary and they were free to discontinue the study at any time. The first stage of the study took place in bigger groups (up to 5 people at a time) in a computer class where the participants got assigned their participant codes and using them as identifiers filled in the computerised versions of IPIP-NEO Facets personality questionnaire (Goldberg et al., 2006). After completing the questionnaire, which lasted up to 45-50 minutes, they signed up for a music-making session, which took place during the following week.

The music-making session lasted 45-60 minutes (including filling in the Profile of Mood States (POMS, McNair et al., 1971) before and after the session). Before music-making, the participants were shortly instructed on the usage of the instruments and were introduced to each other.

During the music-making sessions, a group of 3-4 participants sat in a room which was divided with screens, so that the participants could hear but not see each other, resembling the setup previously used by Koelsch et al. (2010). This room setup was chosen to decrease potential anxiety the participants could experience when they have others watch them play a musical instrument for the first time. Each participant sat in front of a setup of 5 instruments to play with (xylophone, several drums, and percussion instruments). The participants were presented with a collection of predominantly instrumental cheerful musical pieces (described above at the *Stimuli* section) via a sound system. The few pieces with lyrics were in languages the participants were not familiar with (e.g., Romani). Participants played along with the music with their selected instruments. After each piece of music the participants gave liking and familiarity ratings to the piece and rated how pleasant and lively they felt during the piece of music using the valence and arousal scales of the Self-Assessment-Manikins (Bradley and Lang, 1994). After every 2 pieces they swapped places, allowing all participants to try all available instruments as the collection of instruments in each set varied.

6.2.5 Data analysis

SPSS Version 18.0 software was predominantly used for data analysis. Due to the nature and distribution of the data, non-parametric analyses were chosen. For the Profile of Mood States, mean scores for the sub-scales were calculated. Two additional scores were calculated using the following formulas: Arousal = (Anxiety + Vigour) - (Fatigue + Confusion), Positive Mood = Elation - Depression. Friedman's test was used for comparisons of within-group pre-post intervention scores on the POMS sub-scales Anxiety, Depression, Fatigue, Arousal, and Positive mood. Mann-Whitney U-s were computed for between groups (i.e. participants with or without musical training) comparisons of the scores before and after the session.

Median scores for each participant were calculated on the liking, familiarity, valence and arousal ratings as well as for the five IPIP factors. To define the predictors for the change in different aspects of mood, regression analysis was computed using R software (R Development Core Team, 2008) and treating the independent variables as categorical, by estimating the coefficients for all the categories relative to the lowest category (labeled in Tables 6.2 and 6.3 as "Reference"). For regression models the categories for IPIP factors and liking ratings were combined where necessary for comparability.

6.3 Results

The median liking score was 3 out of 4 points, indicating that the participants usually liked the music that accompanied their playing. The majority of the participants was not familiar with the musical pieces (median familiarity rating = 0, where 0 = "not at all" and 4 = "very well"), except for two of the pieces which were relatively well known ("The Lucky Penny" and "Take five" with median familiarity ratings 2 and 3 respectively). The participants felt pleasant (median rating 3 points on a scale of 0 = "extremely unpleasant" and 4 = "extremely pleasant") and lively during the music session (median rating 2.63 points on a scale 0 = "peaceful" and 4 = "lively").

In the group with musical training, liking rating correlated positively with change in arousal and positive mood (r = .343, p = .01 and r = .267, p = .05) and marginally negatively with neuroticism (r = .254, p < .06), whereas in the group without musical training no such correlation was found.

The familiarity rating was positively correlated with the liking rating (r = .217, p = .02), supporting the finding by Witvliet and Vrana (2007) that familiar tunes are liked more, yet, as described above, the familiarity for majority of the musical pieces was low.

6.3.1 Pre-post session mood change

Medians, range and quartiles of the POMS sub-scales for evaluations both before and after the music-making as well as between-measurements differences are shown on Figure 6.1. Floor effects are visible particularly for the Depression scale, where 24 % of the participants scored 0 before the session and 46 % after the session and for 26 % the depression rating did not change. Taking into account the non-clinical nature of the sample, it is to be expected that depression ratings are low. In the remaining 4 POMS sub-scales, the floor effect was less pronounced.

Before the music-making session there was no significant difference in mood between musically trained and untrained participants, except for the Positive mood sub-scale, where musically trained individuals scored lower (U = 896.0, p = .001).

Comparisons of mood ratings before and after music-making showed, that Anxiety, Depression, Fatigue decreased whereas Arousal and Positive Mood increased after the music-making session (see Table 6.1 and Figure 6.2). The direction of the change was as expected for all sub-scales and in line with previous findings (Koelsch et al., 2010). The changes in participants with some musical training were larger in amplitude on all POMS sub-scales (Table 6.1).

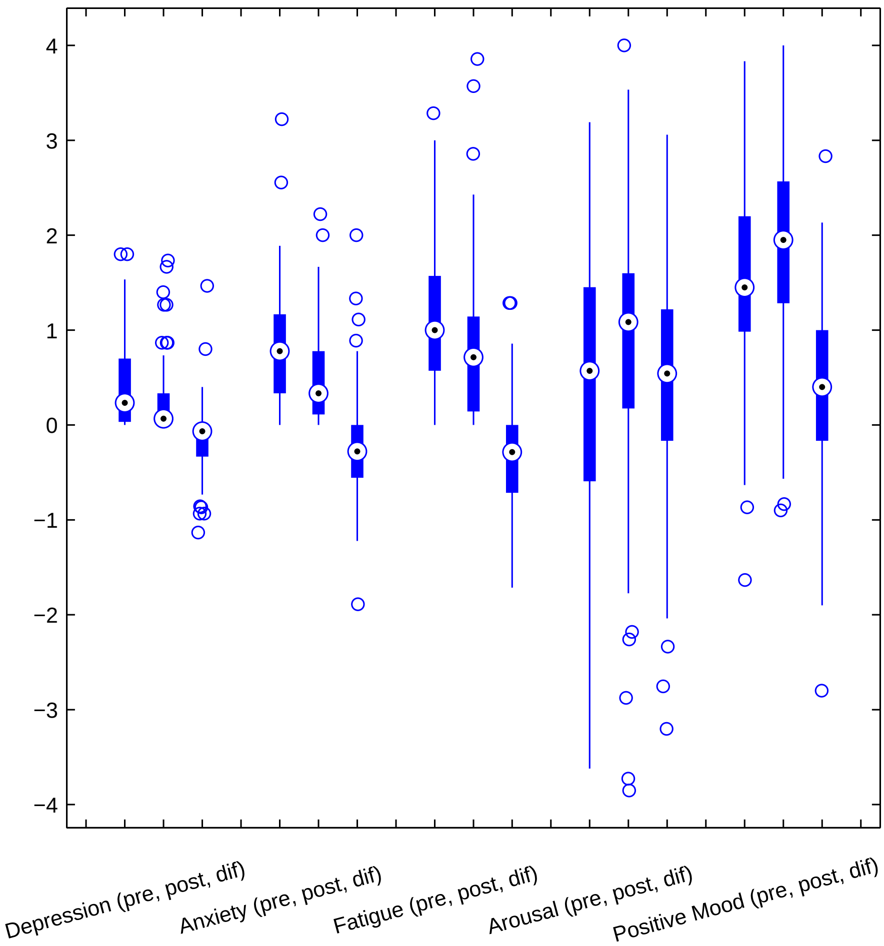

Figure 6.1: Medians, range and quartiles for the POMS sub-scales. The central mark is the median, the edges of the box represent upper and lower quartiles, the whiskers extend to the most extreme data points not considered outliers, and outliers are plotted individually as hollow circles. *Pre* - before the session, *Post* - after the session, *Dif* - difference between pre and post evaluations. $N = 108$.

Table 6.1: *Comparisons of the POMS sub-scales' scores before and after the music-making session for participants with and without musical training.*

	Some musical training			No musical training		
Scale	MR Pre	MR Post	χ^2	MR Pre	MR Post	χ^2
Anxiety	1.79	1.21	21.33 ***	1.75	1.25	14.70 ***
Depression	1.81	1.19	27.22 ***	1.69	1.31	11.77 **
Fatigue	1.80	1.20	25.13 ***	1.71	1.29	11.00 **
Arousal	1.21	1.79	18.29 ***	1.35	1.65	4.92 *
Positive mood	1.21	1.79	20.55 ***	1.41	1.59	1.65

Note: *Pre* - before, *Post* - after; MR = Mean rank; ***$p<.001$, **$p<.01$, *$p<.05$.

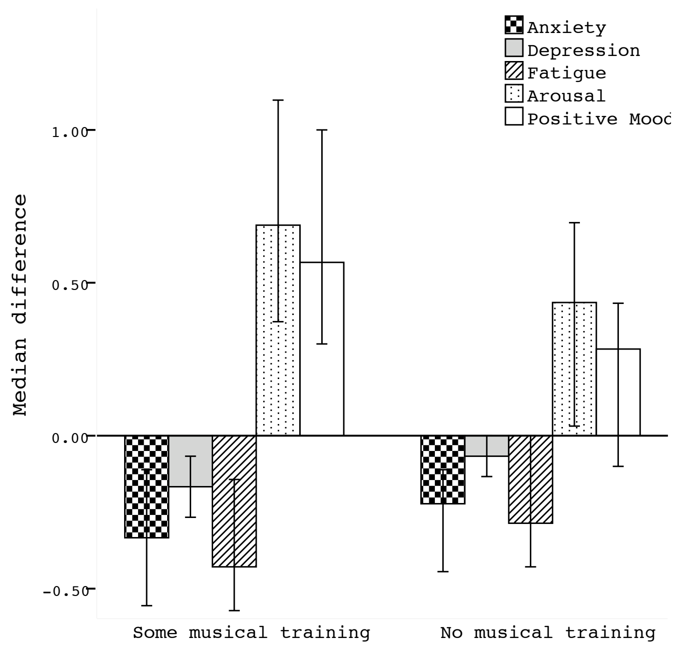

Figure 6.2: Median difference scores on POMS sub-scales between evaluations before and after the music-making for participants with and without musical training. $N = 108$. Error bars represent 95 % confidence intervals.

6.3.2 Mood change and personality

Median score for Neuroticism was 3 points (range 1 - 4) whereas for the remaining 4 factors it was 4 points (ranges 2 - 5 for Extraversion, Agreeableness, and Conscientiousness, 3 - 5 for Openness to Experience), showing that the sample as a whole could be characterized as low in Neuroticism and rather high on the remaining four factors, particularly Openness to experience.

Regression models were computed for changes on all five POMS sub-scales and the estimates for the predictors are shown in Table 6.2 (Depression and Anxiety) and Table 6.3 (Fatigue, Arousal, and Positive mood). Estimates indicate, given the respective value of the predictor, the amount of difference in the predicted variable (e.g., Depression, Anxiety) relative to the lowest category ("Reference" in Tables 6.2 and 6.3) of the predictor (Liking, personality factors, musical training).

A regression model including musical training, Liking and Extraversion scores predicted change in Depression ($R^2 = .18, F(8, 99) = 2.64$,$p$= .012) scores. Median Extraversion scores over 3 points predict increase in the depression scores in comparison to scores below 3, indicating that the depression score decreased more for individuals who are introverted. Higher Liking scores also predicted an increase in depression, yet the relationship with the Liking score was not systematic nor monotonous. Furthermore, musical training predicted a decrease in depression score.

Similarly to Depression, higher median scores in both Liking and Extraversion predicted increase in Anxiety ($R^2 = .20$, $F(9, 97) = 2.62$, $p < .01$), that is, higher Introversion (as the opposite end to the Extraversion dimension) as well as higher median scores (4 and above) in Agreeableness predict a decrease in Anxiety.

A change in Fatigue score was predicted by Openness to Experience, Agreeableness, and musical training ($R^2 = .11, F(5, 101) = 2.48$,$p$= .037). High median Openness to Experience scores (4 and above) predicted increase and high median Agreeableness scores (4 and above) as well as musical training predicted decrease in Fatigue.

Increase in Liking ratings and musical training predicted increase in Arousal and high median scores in Openness to Experience (4 and above) predicted decrease in Arousal ($R^2 = .14, F(7, 99) = 2.37, p = .028$). High scores on Extraversion ((4 and above) and no musical training predicted decrease in Positive mood ($R^2 = .14$, $F(4,\ 102) = 4.04$, $p = .004$).

Table 6.2: *Models for Depression and Anxiety: estimates for the predictors of mood change compared to the lowest category (reference).*

Scale	Reference	Estimate (SE)	*p(>|t|)*
Depression			
(Intercept)		-8.60 (1.99)	3.79e-05 ***
Liking 2	[1,2)	3.53 (1.97)	0.076 .
Liking (2,2.5]		4.64 (2.05)	0.026 *
Liking (2.5,3]		3.36 (1.98)	0.092 .
Liking (3,4]		6.43 (2.48)	0.011 *
Extraversion (3,4)	(2,3]	0.72 (2.70)	0.789
Extraversion 4		1.77 (0.97)	0.073 .
Extraversion (4,5]		4.44 (2.14)	0.041 *
No musical training	Some	1.73 (0.88)	0.053 .
Anxiety			
(Intercept)		-4.71 (2.20)	0.035 *
Liking 2	[1,2)	1.55 (1.96)	0.431
Liking (2,2.5]		3.32 (2.06)	0.110
Liking (2.5,3]		2.28 (1.99)	0.256
Liking (3,4]		6.71 (2.47)	0.008 **
Extraversion (3,4)	(2,3]	-0.33 (2.70)	0.902
Extraversion 4		1.61 (0.98)	0.103
Extraversion (4,5]		5.52 (2.18)	0.013 *
Agreeableness 4	(2,4]	-2.33 (1.33)	0.083 .
Agreeableness (4,5]		-1.09 (1.82)	0.551

Note: ***p<.001, **p<.01, *p<.05, p<.01 The brackets describe the limits between categories, where "[" refers to closed end and "(" to open end of the interval, e.g., "(2,2.5]" refers to an inverval from two (excluded) to 2.5 (included).

Table 6.3: *Models for Fatigue, Arousal, and Positive mood: estimates for the predictors of mood change compared to the lowest category (reference).*

Scale	Reference	Estimate (SE)	$p(>\|t\|)$
Fatigue			
(Intercept)		-3.06 (1.49)	0.042 *
Openness 4	(3,4]	2.25 (1.17)	0.057 .
Openness (4,5]		3.09 (1.49)	0.041 *
Agreeableness 4	(2,4]	-2.54 (1.10)	0.022 *
Agreeableness (4,5]		-2.27 (1.50)	0.133
No musical training	Some	1.43 (0.74)	0.056 .
Arousal			
(Intercept)		6.56 (4.23)	0.124
Liking 2	[1,2)	0.60 (3.58)	0.868
Liking (2,2.5]		2.77 (3.72)	0.457
Liking (2.5,3]		4.58 (3.57)	0.203
Liking (3,4]		6.87 (4.52)	0.132
Openness 4	(3,4]	-4.46 (2.61)	0.091 .
Openness (4,5]		-2.21 (3.37)	0.513
No musical training	Some	-5.33 (1.67)	0.002 **
Positive mood			
(Intercept)		7.75 (1.39)	1.87e-07 ***
Extraversion (3,4)	(2,3]	0.69 (4.08)	0.865
Extraversion 4		-2.21 (1.50)	0.143
Extraversion (4,5]		-5.82 (3.29)	0.080 .
No musical training	Some	-4.17 (1.31)	0.002 **

Note: ***p<.001, **p<.01, *p<.05, . p<.1

6.4 Discussion

The aim of this study was to investigate whether personality traits play a modulating role in the extent to which music can elevate mood in healthy subjects. As found in a previous study using similar method (Koelsch et al., 2010), the participants felt less anxious, depressed and tired after the music-making whereas their level of arousal and positive mood had increased. The current results are in line with these findings, showing that music-making has similar effect on healthy individuals and it may be even stronger for participants with some musical training.

A link between Neuroticism and susceptibility to emotional effects of music was expected, based on finding by Chamorro-Premuzic et al. (2010), suggesting that individuals scoring high on the Neuroticism scale are likely to use music for emotional regulation. The current results do not support this connection. A possible explanation to why this previously reported link with Neuroticism is missing, could be, that the prevalent mood of the music was too different from the preferences of the people scoring high on Neuroticism, as they are likely to prefer sad music (Chamorro-Premuzic et al., 2010). It should also be noted, that the sample contained few individuals scoring very high on Neuroticism, which may also have an impact and for future studies it may be advisable to select the participants to cover both ends of the scales.

In contrast, the results support the connection between susceptibility to the emotional effects of music and the Extraversion - Introversion dimension of personality previously found in the context of the "disturbing" impact of background music on cognitive performance (e.g. Furnham and Strbac, 2002). Low scores in Extraversion, which reflect dominance of Introversion, were related to a decrease in Depression and Anxiety and increase in Positive mood.

Of previously not reported links, high Agreeableness was related to a decrease in Fatigue, whereas high Openness to Experience predicted increase in Fatigue and decrease in Arousal. Moreover, musical training was related to a number of positive changes – decrease in Depression and Fatigue and increase in Arousal and Positive mood. Liking of the accompanying music had an effect on changes in Depression, Anxiety, and Arousal.

It may seem surprising, that participants, who strongly liked the music used in the session, showed less decrease in depression, but it must be noted that their depression scores were low to start with. This was a healthy population sample, of which a quarter scored 0 on the Depression scale before and 46% after the music-making, and therefore a large proportion could show only minimal improvement on a depression measure. At the same time, they gave high liking ratings to the music whereas participants showing larger improvement on the depression scale – as there was space for improvement – gave moderate liking ratings.

The results showed that high scores in Openness to Experience were related to increase in Fatigue and decrease in Arousal, perhaps because individuals scoring high on Openness to Experience are found to use music predominantly for intellectual pleasure (Chamorro-Premuzic et al., 2010). They appreciate novel complex music and do not usually use music for emotional regulation, perhaps because music has a smaller impact on their mood. The music used in this study (predominantly structurally rather simple, as folk music often is) may also not have been a good match with their usual preference, hence not being particularly stimulating for this specific subsample.

The connection between high Agreeableness scores and decrease in Fatigue could be explained by the social, co-operational nature of the session setup, which such individuals would enjoy.

The difference between the participants groups with and without musical training, with more pronounced effects in the musically trained group, could perhaps indicate that people with musical training are more susceptible to the mood changing properties of music. The difference between people with and without musical training is also apparent it the regression models, where stronger positive mood changes are predicted for participants with musical training. However, it remains unclear whether it is due to the individuals emotionally sensitive to music choosing to learn to play an instrument or musical training contributing to the increased sensitivity. People who are more prone to be influenced by music may expose themselves to music more or start learning an instrument as this is a relatively simple and easily accessible way to experience pleasure (Blood and Zatorre, 2001). This increased exposure may in turn increase the sensitivity.

It is important to note, that participants with musical training in this study were not musicians – they were students with a small number of years of musical training – yet, it had an impact on their mood change. It would be interesting to explore these effects with professional musicians, as there is surprisingly little to find in the literature on musicians' emotional processing of music. In one account it was found that musicians, while performing, process musical emotions differently from amateur musicians or musically untrained individuals (Parsons et al., 2005), leaving open questions about, whether this affects their general ability to emotionally enjoy music and which developmental changes have resulted in such an effect.

In conclusion, music-making improved the mood of healthy participants and personality traits seem to modulate this effect in several aspects. More specifically, Introversion was related to a decrease in Depression and Anxiety and increase in Positive mood, Agreeableness was related to a decrease in Fatigue and Openness to Experience predicted increase in Fatigue and decrease in Arousal. In addition, it was found that musical training was related to a number of positive changes – decrease in Depression and Fatigue and increase in Arousal and Positive mood, suggesting that music improves mood more in people who make music themselves.

6.5 List of Stimuli

Author	Title
Jonathan Richman	Egyptian Reggae
Ron Goodwin	Theme from Miss Marple
Ruben Gonzalez	Fabiando
Parno Graszt	Ravagok a zongorara
New Celtic Dimension	The Lucky Penny
Ruben Gonzales	Enriqueta
The Gas Band	An Angel Went Up in Flames
Paul Desmond	Take five

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[1]

[1]The numbers following the references indicate the page numbers in the thesis where the source has been cited.

Appendices

Appendix A

Ethics Committee Approvals

University of Sussex
School of Life Sciences Research Governance Committee

CERTIFICATE OF APPROVAL

Title of Project	**:Is musical scale information processed automatically?**
Principal Investigator	**Dr. Stefan Kölsch**
Student	**Tiina Kalda**
Collaborators	
Duration of approval (not greater than 4 years)	6 months

This project has been given ethical approval by the School of Life Sciences Research Governance Committee.

NB. If the actual project start date is delayed beyond 12 months of the expected start date, this Certificate of Approval will lapse and the project will need to be reviewed again to take account of changed circumstances such as legislation, sponsor requirements and University procedures.

Please note and follow the requirements for approved submissions:
Amendments to protocol.
• Any changes or amendments to approved protocols must be submitted to the committee for authorisation prior to implementation.

Feedback regarding the status and conduct of approved projects
• Any incidents with ethical implications that occur during the implementation of the project must be reported immediately to the Chair of the committee.

The principal investigator is required to provide a brief annual written statement to the committee, indicating the status and conduct of the approved project. These reports will be reviewed at the annual meeting of the committee. A statement by the Principal Investigator to the Committee indicating the status and conduct of the approved project will be required on the following date(s):

December 2009…………………………………………………………………………………

Signed: ………….. Jennifer Rusted…………………..
Chair of the Research Governance Committee

Date: ……6 March 2009……………….

Figure A.1: Behavioural and EEG studies.

University of Sussex
School of Life Sciences Research Governance Committee

CERTIFICATE OF APPROVAL

Title of Project	**Is musical scale information processed automatically: comparison of musicians and non-musicians?**
Principal Investigator	**Dr. Stefan Kölsch**
Student	**Tiina Kalda**
Collaborators	
Duration of approval (not greater than 4 years)	9 months

This project has been given ethical approval by the School of Life Sciences Research Governance Committee.

NB. If the actual project start date is delayed beyond 12 months of the expected start date, this Certificate of Approval will lapse and the project will need to be reviewed again to take account of changed circumstances such as legislation, sponsor requirements and University procedures.

Please note and follow the requirements for approved submissions:
Amendments to protocol.
• Any changes or amendments to approved protocols must be submitted to the committee for authorisation prior to implementation.

Feedback regarding the status and conduct of approved projects
• Any incidents with ethical implications that occur during the implementation of the project must be reported immediately to the Chair of the committee.

The principal investigator is required to provide a brief annual written statement to the committee, indicating the status and conduct of the approved project. These reports will be reviewed at the annual meeting of the committee. A statement by the Principal Investigator to the Committee indicating the status and conduct of the approved project will be required on the following date(s):

December 2009, December 2010

Signed: ………….. …Jennifer Rusted……………….
Chair of the Research Governance Committee

Date: …………24 October 2009…………….

Figure A.2: Behavioural and EEG studies: Extension.

NHS
National Research Ethics Service
Brighton East Research Ethics Committee
Brighton & Hove City Teaching PCT
2nd Floor, Prestamex House
171-173 Preston Road
Brighton
East Sussex
BN1 6AG

Telephone: 01273 545373
Facsimile: 01273 545372

06 October 2008

Ms Tiina Kalda
PhD Candidate
University of Sussex
Department of Psychology
Pevensey Building
Brigghton
BN1 9QH

Dear Ms Kalda

Full title of study:	**Can music-making improve the condition of depressed patients?**
REC reference number:	**08/H1107/131**

Thank you for your letter of 25 September 2008, responding to the Committee's request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Vice-Chair.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Ethical review of research sites

The Committee has designated this study as exempt from site-specific assessment (SSA). The favourable opinion for the study applies to all sites involved in the research. There is no requirement for other Local Research Ethics Committees to be informed or SSA to be carried out at each site.

Conditions of the favourable opinion

The favourable opinion is subject to the following conditions being met prior to the start of the study.

Management permission or approval must be obtained from each host organisation prior to the start of the study at the site concerned.

Management permission at NHS sites ("R&D approval") should be obtained from the relevant care organisation(s) in accordance with NHS research governance arrangements. Guidance on applying for NHS permission is available in the Integrated Research Application System or at http://www.rdforum.nhs.uk.

Figure A.3: Depression case series: NREC, page 1

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document	*Version*	*Date*
Covering Letter		14 July 2008
Investigator CV		17 July 2008
CV of educational supervisor		05 April 2008
Participant Consent Form		10 July 2008
GP/Consultant Information Sheets		10 July 2008
List of music and poems		17 July 2008
Advertisement		14 July 2008
Questionnaire: SAM		
Questionnaire: HAMD		
Questionnaire: PHQ9		
Questionnaire: POMS		
Questionnaire: BDI		
Compensation Arrangements		27 July 2007
Questionnaire: General personal information		
Response to Request for Further Information		25 September 2008
Application		25 September 2008
Protocol	4	22 September 2008
Participant Information Sheet	4 - appendix A	23 September 2008
Flyer for Participants	4 - appendix B	22 September 2008
GP/ consultant information sheets	4 - appendix D	22 September 2008

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees (July 2001) and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

After ethical review

Now that you have completed the application process please visit the National Research Ethics Website > After Review

You are invited to give your view of the service that you have received from the National Research Ethics Service and the application procedure. If you wish to make your views known please use the feedback form available on the website.

The attached document "After ethical review – guidance for researchers" gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments
- Progress and safety reports
- Notifying the end of the study

The NRES website also provides guidance on these topics, which is updated in the light of changes in reporting requirements or procedures.

Figure A.4: Depression case series: NREC, page 2

08/H1107/131 Page 3

We would also like to inform you that we consult regularly with stakeholders to improve our service. If you would like to join our Reference Group please email referencegroup@nres.npsa.nhs.uk.

08/H1107/131	**Please quote this number on all correspondence**

With the Committee's best wishes for the success of this project

Yours sincerely

pp

Chair
Dr Paul Seddon

Email: nischinth.cherodian@bhcpct.nhs.uk

Enclosures: "After ethical review – guidance for researchers"

Copy to: Professor Jennifer Rusted
Professor of Experimental Psychology
Department of Psychology
Pevensey Building
University of Sussex
Brighton
BN1 9QH

Figure A.5: Depression case series: NREC, page 3

University of Sussex
School of Life Sciences Research Governance Committee

Sponsorship application:
CERTIFICATE OF APPROVAL

Title of Project: Can music-making improve the condition of depressed patients?
Principal Investigator: Dr Stephan Koelsch
Student: Tiina Kalda
Collaborators: Dr Richard Whale; Dr Ronny Enk
Duration of approval (not greater than 4 years) **3 years**

This project has been given ethical approval by the School of Life Sciences Research Governance Committee, and the Committee will sponsor the project *subject to approval of the proposal by the LREC Committee* (please submit a copy of the approval when obtained).

A statement by the Principal Investigator to the School Committee indicating the status and conduct of the approved project will be required on the following date(s):

DECEMBER 2009, 2010, 2011 , to be submitted to the Secretary of the Committee on request

Signed: ……………Jennifer Rusted………………………………………
Chair of the Research Governance Committee
Date: …………………19 October 2008………………………………

Please note and follow the requirements for approved submissions:

Amendments to protocol.
Any changes or amendments to approved protocols must be submitted to the Committee for authorisation prior to implementation.

Feedback regarding the status and conduct of approved projects
Any incidents with ethical implications that occur during the implementation of the project must be reported immediately to the Chair of the Committee

Figure A.6: Depression case series: University of Sussex

Ethics Review Committee (ERC) on Human Research of the University of Tartu

Operating to all ICH GCP requirements

Approval 181/T-15

Member name	Qualification	Occupation	Affiliation
Chairman:			
Andres Soosaar	MD, PhD	Docent	Faculty of Medicine, University of Tartu
Vice-chairman			
Arvo Tikk	MD, PhD, DSc	Professor emeritus	Faculty of Medicine, University of Tartu
Members			
Eve-Merike Sooväli	RN, MNSc	Lecturer	Tartu School of Health Care
Kaia Kastepõld-Tõrs	MSc	Lecturer	Faculty of Social Sciences, University of Tartu
Kristi Lõuk	–	Project manager	Faculty of Philosophy, University of Tartu
Oivi Uibo	MD, PhD	Docent	Faculty of Medicine, University of Tartu
Maire Link	MD	Postgraduate student	Faculty of Medicine, University of Tartu
Naatan Haamer	–	Hospital Chaplan	Tartu University Clinics
Aime Keis	MD	Project manager	Estonian Genome Foundation, University of Tartu
Riina Kallikorm	MD, PhD	Docent	Dept. of Internal medicine, University of Tartu

Investigators' names:

Stefan Koelsch (Sussexi Ülikool, Department of Psychology, Pevensey Building, University of Sussex Brighton, BN1 9QH, United Kingdom)

Protocol title:

Music-making with patients suffering from depression.

Documents reviewed:

1. Application Form to the Ethics Review Committee on Human Research of the University of Tartu

Approval is given to continue.

Date of ERC Meeting: 20.04.2009

Chairman of ERC: docent Andres Soosaar

Secretary of ERC: Ave Jalakas

University of Tartu
Office of Research and Institutional Development
Ülikooli 18
50090, Tartu, Estonia

Phone: (+372) 7 375 617
Fax: (+372) 7 375 508

Figure A.7: Depression group comparison.

University of Sussex
School of Life Sciences Research Governance Committee

CERTIFICATE OF APPROVAL

Title of Project	**The role of personality in the mood-modulating effect of music-making.**
Principal Investigator	**Dr. Stefan Kölsch**
Student	**Tiina Kalda**
Collaborators	
Duration of approval (not greater than 4 years)	9 months

This project has been given ethical approval by the School of Life Sciences Research Governance Committee.

NB. If the actual project start date is delayed beyond 12 months of the expected start date, this Certificate of Approval will lapse and the project will need to be reviewed again to take account of changed circumstances such as legislation, sponsor requirements and University procedures.

Please note and follow the requirements for approved submissions:
Amendments to protocol.
- Any changes or amendments to approved protocols must be submitted to the committee for authorisation prior to implementation.

Feedback regarding the status and conduct of approved projects
- Any incidents with ethical implications that occur during the implementation of the project must be reported immediately to the Chair of the committee.

The principal investigator is required to provide a brief annual written statement to the committee, indicating the status and conduct of the approved project. These reports will be reviewed at the annual meeting of the committee. A statement by the Principal Investigator to the Committee indicating the status and conduct of the approved project will be required on the following date(s):

December 2009, December 2010

Signed: ………….. …Jennifer Rusted………………..
Chair of the Research Governance Committee

Date: …………6 NOVEMBER 2009…………….

Figure A.8: Personality and music-making.

Appendix B

Information sheets

Scale-information processing

Information for participants

Thank you for your interest in participating in our study!

During the experiment you will listen to a melody, in which some notes are played on a different instrument. Please press the response button every time you hear the note played on a different instrument. During the whole experiment the electroencephalogram (EEG) will be recorded (EEG procedure is described on a separate sheet).

Please attempt to keep movement to a minimum during the testing and, most importantly, try to blink your eyes as infrequently as possible (there are short breaks in the melody when you can move yourself, if necessary, and blink your eyes).

The EEG recording session takes about 35 min, the whole procedure (including EEG preparation) will take about 2 hours.

All personal information will be handled confidentiality according to data protection regulations. The data will be used for scientific purposes only. Results will not be reported back individually to participants.

Participation is entirely voluntary. You are free to withdraw from the study at any time without explanation.

Precautions:
You should not take part if you:

1. suffer from any neurological impairments.
2. suffer from any skin conditions.
3. take medication for depression.
4. have a cold or flu or getting over a cold or flu at the time you intend to participate.
5. have suffered severe head injury in your lifetime.
6. suffer from an ear infection or a hearing impairment, such as perforated eardrum.

If you have any questions, please do not hesitate to ask.

If you have

- read the information above and understood it,
- asked questions if you wanted to, and got satisfactory answers,
- understood that you are free to withdraw from the experiment at any time without explanation, then

please sign below to indicate that you agree to take part in the study.

Name___________________________________

Signature: _______________________ Date: __________________

Figure B.1: EEG study, page 1.

RECORDING EVENT-RELATED POTENTIALS (ERPs)

In order that we can measure your brain activity, we need to make sure your scalp and head are properly prepared. In order to do this, we need to complete the following:

- thorough brushing of hair
- clean skin around the eyes, ears and forehead using alcohol
- fit Quik-Cap and attach electrodes around the eyes and ears
- insert saline solution into the Quik-Cap to build a connection
- lightly abrade the scalp using a blunted needle and stick

After the experiment has been completed, you will be asked to:

- take the cap off
- clean and wash your hair

Using this procedure, we are able to see how your brain responds to various visual and auditory stimuli, often without you having to respond behaviourally to the stimuli at all. This way, we can figure out what the brain can do on its own and compare this with what happens when attention is directed towards these events.

Ultimately, understanding the function of the healthy brain using ERP recording will help us understand what happens when brain functioning changes as a result of illness or aging. Highlighting the differences between these two sets of processes will assist in the development of better rehabilitation techniques.

Although you might feel slight discomfort, there are no known long term risks associated with this procedure. We would like to remind you that if wish to withdraw at any point during the preparation stage, or at any point during the experiment, you are free to do so.

IMPORTANT

If you have temporal-mandibular joint (TMJ) disease then you should not wear the Quik-Cap.

Figure B.2: EEG study, page 2.

23/09/2008, Version 4

University of Sussex	Tiina Kalda Department of Psychology Pevensey Building University of Sussex Brighton BN1 9QH United Kingdom T.Kalda@sussex.ac.uk Telephone: +44 1273 872547

Audio-intervention for depression

Information for participants

Thank you for considering becoming involved in our study. Please read the following information carefully about the background, procedure and potential risks involved. If you have any questions, please do not hesitate to ask.

Scientific background

We are investigating the emotional and simple bodily effects of listening to music or an audio book. This has been studied previously in a healthy adult group, who met for one session and reported it to have a positive influence on their mood. Now we would like to investigate this over several sessions in individuals suffering from low mood.

Procedure

The experiment consists of six 1-hour sessions, which take place once a week. One group of participants will be asked to listen to and play some music and the other group to listen to an audio book and solve a puzzle. The group which participants join will be decided randomly by a computer program: The computer will randomly assign either the number one or the number two to each participant. Participants with number two will be assigned to the music group, those with number one to the audio book group. Following the 6 week study period participants may switch groups if they wish to continue this experience.

At a 30 minute screening session before the study starts, a clinical interview for depression will be conducted.

Questionnaires will be used regularly at each session to evaluate emotional state and mood (two at the beginning and one at the end of each session) and it will take 10-15 minutes of the session time.

Changes in pulse rate occur with changes in emotional state and this will be monitored during each audio session using heart beat recording equipment (an ECG) with electrical sensors on the arms, legs, and chest. This will not be set up to identify any heart or pulse abnormalities.

Figure B.3: Depression case series, page 1.

23/09/2008, Version 4

Possible risks and complications

Participants will not be exposed to any risk beyond the gentle exercise involved in playing music. The same procedures have been used before in healthy adults. This procedure will not affect the usual treatment of any illness by your doctor. In the unlikely event of medical problems arising during the experiment, a nominated doctor will be contacted.

Confidentiality

All personal information will be handled confidentiality by the named investigators according to data protection regulations. The data will be used for scientific purposes only. Results will not be reported back individually to participants.

GPs will be informed about involvement this experiment unless an objection is made by a participant.

Involvement with this study is entirely voluntary and participants are free to withdraw from the procedure at any time without explanation. The data already collected will be used in the study.

The study has been reviewed by the local ethics committee. If you have any questions about the study, please contact Dr. Stefan Koelsch, at the University of Sussex: Tel. 01273-872776 or by email at s.koelsch@sussex.ac.uk; or Tiina Kalda, at the University of Sussex: Tel. 01273-872547 or by email at t.kalda@sussex.ac.uk.

2

Figure B.4: Depression case series, page 2.

Tiina Kalda
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Suurbritannia
T.Kalda@sussex.ac.uk
Telefon: +3725169432

Patsiendi infoleht uuringu kohta:

"Kas musitseerimine või audio-raamatu kuulamine aitab depressiooni vastu?".

Täname, et kaalute osalemist meie uuringus. Palun lugege hoolikalt järgnevat informatsiooni uuringu eesmärkide, läbiviimise ja võimalike ohtude kohta. Kui Teil on küsimusi, esitage need julgesti!

Mida uurime:

Me uurime muusika ja audio-raamatu kuulamise mõju inimeste meeleolule ja füsioloogilistele reaktsioonidele. Seda on varem uuritud tervete täiskasvanute rühmal, mille liikmed osalesid ühel sessioonil ning leiti, et sel oli positiivne mõju nende meeleolule. Nüüd tahame uurida korduvate seansside mõju inimestele, kes kannatavad depressiooni all.
Mõju hindamiseks kasutame erinevaid mõõtmisi: vereproove, kuna depressioonil on leitud olevat seos muutustega immuunsüsteemi aktiivsuses, ning küsimustikke ja intervjuud, et saada teada kuidas Te end selle protsessi vältel tunnete.

Läbiviimine

Esimesel kohtumisel viiakse läbi depressiooni kliiniline intervjuu. Samuti palutakse Teil täita mõned küsimustikud ning võetakse vereproov.

Katse koosneb kümnest 1-tunnisest kokkusaamisest, mis toimuvad kahe nädala jooksul iga tööpäeva hommikul. Ühel osalejate rühmal palutakse kuulata ja kaasa mängida mõnedele muusikapaladele ja teine rühm saab kuulata audio-raamatut ja joonistada. Seda, kumba rühma Te satute, otsustab juhuvaliku teel arvutiprogramm.

Igal kohtumisel palutakse Teil täita küsimustikud, et hinnata Teie emotsionaalset seisundit ja meeleolu. Nende täitmiseks kulub umbkaudu 10-15 minutit.
Vereproove võetakse kokku 5 korral, ligikaudu kord nädalas: enne esimest intervjuud, enne esimest muusika või audio-raamatu seanssi, esimese nädala lõpus, enne viimast seanssi teise nädala lõpus ning jätkukohtumisel 2-4 nädalat hiljem.

2-4 nädalat pärast viimast seanssi viiakse läbi veel üks intervjuu ning võetakse viimane vereproov. Seejärel on osalejatel võimalus esitada küsimusi, kui neid peaks olema ning avaldada arvamust katses osalemise kohta.

Figure B.5: Depression group comparison, page 1.

Võimalikud riskid ja komplikatsioonid

Uuringu protseduurid ei kujuta endast osalejatele suuremat ohtu kui seda on kerge kehaline aktiivsus muusikainstrumentide käsitsemisel või muu kerge käelise tegevuse juures või standardne vereproovide võtmise protseduur. Sama katseülesehitust on varem kasutatud tervetel täiskasvanutel. Osalemine selles uuringus ei mõjuta Teie tavapärast ravi. Juhul kui katse ajal ilmnevad meditsiinilised probleemid, võetakse ühendust arstiga.

Konfidentsiaalsus

Kõiki isikuandmeid käsitletakse konfidentsiaalselt vastavalt andmekaitse eeskirjadele. Andmed anonümiseeritakse ning tuvastamist võimaldav info hoitakse turvalises kohas ülejäänud andmetest eraldi. Andmetele on ligipääs ainult uurimisgrupi liikmetel ning neid kasutatakse üksnes teaduslikul eesmärgil - osana T.Kalda doktoritööst ning avaldamiseks teadusajakirjas. Infot mis otseselt puudutab Teie seisundit, jagatakse Teie nõusolekul Teie raviarstiga. Osalejaid ei teavitata tulemustest individuaalselt.

Käesolevas uuringus osalemine on täiesti vabatahtlik ja Te võite osalemisest loobuda igal ajal oma otsust põhjendamata. Juba kogutud andmeid kasutatakse uuringus.

Uuringu on heaks kiitnud kohalik eetikakomitee. Kui teil on küsimusi uuringu kohta, võtke ühendust Dr Stefan Koelschiga, Sussexi Ülikoolis: e-mail: s.koelsch@sussex.ac.uk (inglise keeles) või Tiina Kaldaga, Tel. +3725169432 või e-mail: t.kalda@sussex.ac.uk.

Figure B.6: Depression group comparison, page 2.

Personality, mood & music-making
Information for participants

We thank you for willingness to be involved in our study. Please read carefully the following information about the background and procedure of the experiment, as well as possible risks. If you have any questions, please do not hesitate to ask.

Scientific background

We are interested in investigating emotional and physiological effects of listening to music and playing along with it. Previous studies in healthy subjects have shown beneficial effects.

Procedure

The experiment will consist of two parts: a meeting where you are asked to fill in some questionnaires on a computer about your mood, stress and personality and complete a short music-listening task; and a music-making session in a 3-people-group, where you will listen to and play some music using simple instruments. You will be asked to fill in a few questionnaires also before and after the music-making session, which will be used to estimate your emotional state (or mood) and stress level.

Possible risks and complications

Participants will not be exposed to any risk. The same procedures have been used before in healthy adults.

Confidentiality

All personal information will be handled confidentiality by the named investigators according to data protection regulations. The data will be used for scientific purposes only. Results will not be reported back individually to participants.

Participation is entirely voluntary. You are free to withdraw from the study at any time without explanation. The data already collected will be used in the study.

The study has been approved by the local ethics committee. If you have any questions about the study, please contact Tiina Kalda, at the University of Sussex: Tel. 01273-872826 or by email at t.kalda@sussex.ac.uk.

If you have:

- Read the information above and understood it;
- Asked questions if you wanted to, and got satisfactory answers;
- Understood that you are free to withdraw from the experiment at any time without explanation.

Please sign below to indicate that you agree to take part in the study.

Name___________________________________

Signature: _______________________ Date: ___________________

Figure B.7: Personality and music-making.

Appendix C

Questionnaires

Name.. Session........... Date.......................................

BDI

On this questionnaire are groups of statements. Please read each group of statements carefully. Then pick out the one statement in each group which best describes the way you have been feeling in the PAST WEEK, INCLUDING TODAY; Circle the number beside the statement you picked. If several statements in the group seem to apply equally well, circle each one. Be sure to read all the statements in each group before making a choice.

1.
0 I do not feel sad
1 I feel sad
2 I am sad all the time and I cannot snap out of it
3 I am so sad or unhappy that I can't stand it

2.
0 I am not particularly discouraged about the future
1 I feel discouraged about the future
2 I feel I have nothing to look forward to
3 I feel that the future is hopeless and that things cannot improve

3.
0 I do not feel like a failure
1 I feel I have failed more than the average person
2 As I look back on my life, all I can see is a lot of failures
3 I feel I am a complete failure as a person

4.
0 I get as much satisfaction out of things as I used to
1 I don't enjoy things the way I used to
2 I don't get real satisfaction out of anything anymore
3 I am dissatisfied or bored with everything

5.
0 I don't feel particularly guilty
1 I feel guilty a good part of the time
2 I feel quite guilty most of the time
3 I feel guilty all of the time

6.
0 I don't feel I am being punished
1 I feel I may be punished
2 I expect to be punished
3 I feel I am being punished

7.
0 I don't feel disappointed in myself
1 I am disappointed in myself
2 I am disgusted with myself
3 I hate myself

1

Figure C.1: Beck Depression Inventory (BDI), page 1.

Name.. Session........... Date..

8.	0	I don't feel I am any worse than anybody else
	1	I am critical of myself for my weaknesses or mistakes
	2	I blame myself all the time for my faults
	3	I blame myself for everything bad that happens
9.	0	I don't have any thoughts of killing myself
	1	I have thoughts of killing myself, but I would not carry them out
	2	I would like to kill myself
	3	I would kill myself if I had the chance
10.	0	I don't cry any more than usual
	1	I cry more now than I used to
	2	I cry all the time now
	3	I used to be able to cry, but now I can't cry even though I want to
11.	0	I am no more irritated now than I ever am
	1	I get annoyed or irritated more easily than I used to
	2	I feel irritated all the time now
	3	I don't get irritated at all by the things that used to irritate me
12	0	I have not lost interest in other people
	1	I am less interested in other people than I used to be
	2	I have lost most of my interest in other people
	3	I have lost all of my interest in other people
13.	0	I make decisions as well as I ever could
	1	I put off making decisions more than I used to
	2	I have greater difficulty in making decisions than before
	3	I can't make decisions at all any more
14.	0	I don't feel I look any worse than I used to
	1	I worry that I am looking old or unattractive
	2	I feel there are permanent changes in my appearance that make me look unattractive
	3	I believe that I look ugly
15.	0	I can work about as well as before
	1	It takes an extra effort to get started at doing something
	2	I have to push myself very hard to do anything
	3	I can't do any work at all

Figure C.2: Beck Depression Inventory (BDI), page 2.

Name.. Session........... Date.......................................

16.	0	I can sleep as well as usual
	1	I don't sleep as well as I used to
	2	I wake up 1-2 hours earlier than usual and find it hard to get back to sleep
	3	I wake up several hours earlier than I used to and cannot get back to sleep
17.	0	I don't get more tired than usual
	1	I get tired more easily than I used to
	2	I get tired from doing almost anything
	3	I am too tired to do anything
18.	0	My appetite is no worse than usual
	1	My appetite is not as good as it used to be
	2	My appetite is much worse now
	3	I have no appetite at all any more
19.	0	I haven't lost much weight, if any, lately
	1	I have lost more than 5 pounds
	2	I have lost more than 10 pounds
	3	I have lost more than 15 pounds
		I am purposely trying to lose weight by eating less: YES___ NO___
20.	0	I am no more worried about my health than usual
	1	I am worried about physical problems such as aches and pains: or upset stomach: or constipation
	2	I am very worried about physical problems and its hard to think of much else
	3	I am so worried about my physical problems that I cannot think about anything else
21.	0	I have not noticed any recent change in my interest in sex
	1	I am less interested in sex than I used to be
	2	I am much less interested in sex now
	3	I have lost interest in sex completely

3

Figure C.3: Beck Depression Inventory (BDI), page 3.

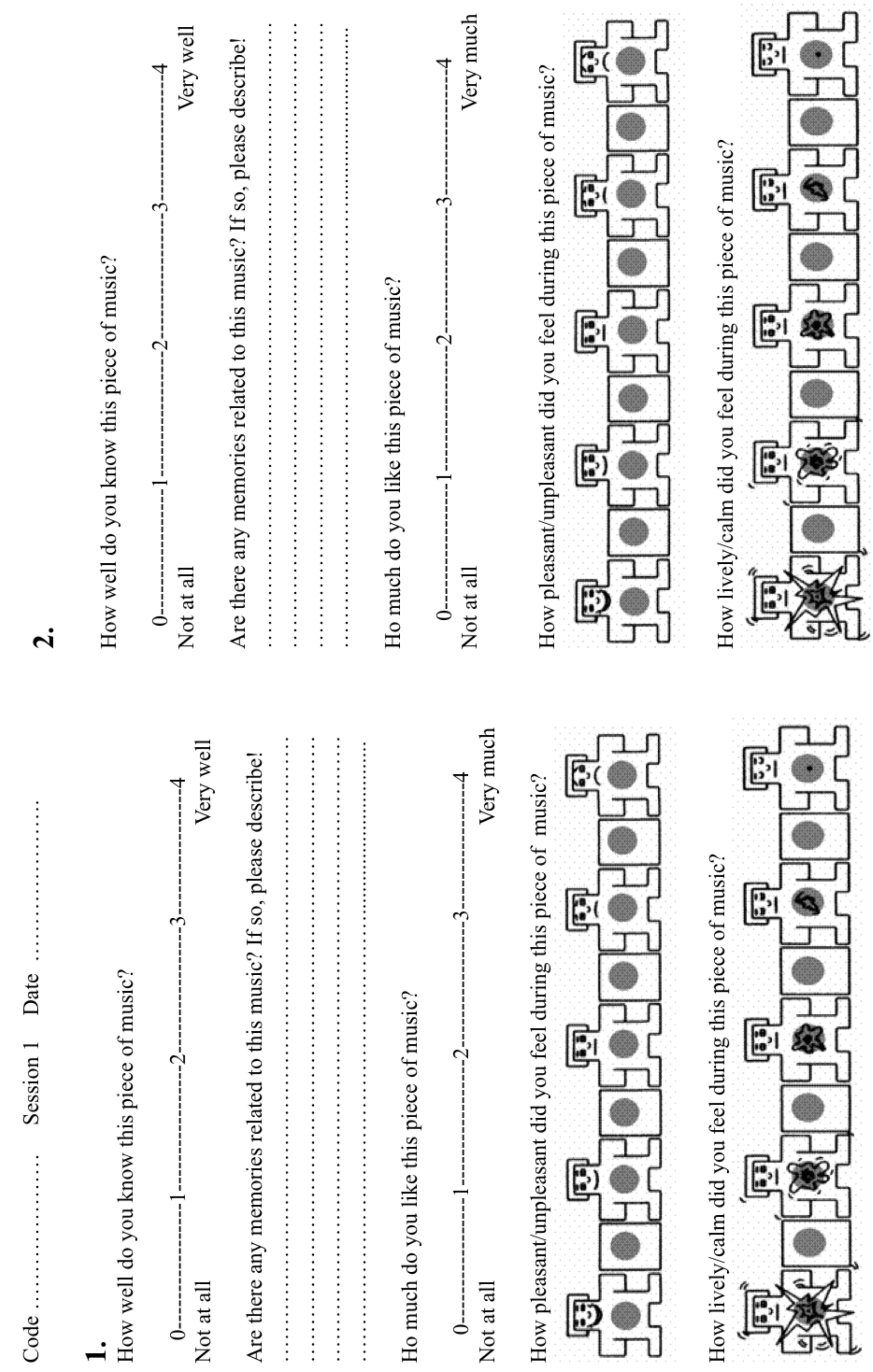

Figure C.4: Evaluation form for each piece of music during the session.

Participant code:………………..

General personal data

Date of birth:…………….

Sex: M / F

Education………………………….

Musical training: ………………………………………………………………………..........
…………………………………………………………………………………………………

Pregnancy Y/N

Legal/illegal drugs: Y / N...……………………………………………………………...
…………………………………………………………………………………………………
Smoking Y/N ………per day. Alcohol ………..units per week

Neurological problems: Y / N …………………………………………………………...
…………………………………………………………………………………………………

Immunolgical problems Y/N ……………………………………………………………
……………………………………………………………………………………………...

Other psychiatric diagnoses: Y / N ……………………………………………………..
…………………………………………………………………………………………………
…………………………………………………………………………………………………

Depression history: ……………………………………………………………………...
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………

Current medication: ……………………………………………………………………..
…………………………………………………………………………………………………
…………………………………………………………………………………………………

Other (previous) therapies: ..……………………………………………………………….
…………………………………………………………………………………………………
…………………………………………………………………………………………………

Figure C.5: General information questionnaire.

UNIVERSITY HEALTH SYSTEM

HAMILTON DEPRESSION RATING
(17-Items)

Date: ______________________

❑ Critical Visit ❑ F/U Visit

❑ Admission ❑ Outpatient MH ❑ Psychiatric Emergency Service
❑ Discharge ❑ Outpatient ATC

	RATING (circle)
1 DEPRESSED MOOD (Sadness, hopeless, helpless, worthless) 0 Absent 1 These feeling states indicated only on questioning 2 These feelings spontaneously reported verbally 3 Communicates feeling states non-verbally--i.e., through facial expression, posture, voice, and tendency to weep 4 Patient reports VIRTUALLY ONLY these feeling states in his spontaneous verbal and non-verbal communication	0 1 2 3 4
2 FEELINGS OF GUILT 0 Absent 1 Self-reproach, feels he has let people down 2 Ideas of guilt or rumination over past errors or sinful deeds 3 Present illness is a punishment. Delusions of guilt 4 Hears accusatory or denunciatory voices and/or experiences threatening visual hallucinations	0 1 2 3 4
3 SUICIDE 0 Absent 1 Feels life is not worth living 2 Wishes he were dead or any thoughts of possible death to self 3 Suicide ideas or gesture 4 Attempts at suicide (any serious attempt rates 4)	0 1 2 3 4
4 INSOMNIA EARLY 0 No difficulty falling asleep 1 Complaints of occasional difficulty falling asleep - i.e., more than 1/2 hour 2 Complains of nightly difficulty falling asleep	0 1 2
5 INSOMNIA MIDDLE 0 No difficulty 1 Patient complaints of being restless and disturbed during the night 2 Waking during the night - any getting out of bed rates 2 (except for purpose of voiding)	0 1 2
6 INSOMNIA LATE 0 No difficulty 1 Waking in early hours of the morning but goes back to sleep 2 Unable to fall asleep again if gets out of bed	0 1 2
7 WORK AND ACTIVITIES 0 No difficulty 1 Thoughts and feelings of incapacity, fatigue or weakness related to activities, work or hobbies 2 Loss of interest in activity, hobbies or work - either directly reported by patient, or indirect in listlessness, indecision and vacillation (feels he has to push self to work or join activities) 3 Decrease in actual time spent in activities or decrease in productivity. 4 Stopped work because of present illness. In hospital, rate 4 if patient engages in no activities (group).	0 1 2 3 4

Hamilton Depression Rating
BCHD# 306 NS 4/99

Chart Order #
IP 365 OP 150

Figure C.6: Hamilton Depression Rating Scale (HAMD), page 1.

		RATING (circle)				
8	**RETARDATION** (Slowness of thought and speech; impaired ability to concentrate; decreased motor activity) 0 Normal speech and thought 1 Slight retardation at interview 2 Obvious retardation at interview 3 Interview difficult 4 Complete stupor	0	1	2	3	4
9	**AGITATION** 0 None 1 Fidgetiness 2 "Playing with" hands, hair, etc. 3 Moving about, can't sit still 4 Hand-writing, nail-biting, hair-pulling, biting of lips	0	1	2	3	4
10	**ANXIETY PSYCHIC** 0 No difficulty 1 Subjective tension and irritability 2 Worrying about minor matters 3 Apprehensive attitude apparent in face or speech 4 Fears expressed without questioning	0	1	2	3	4
11	**ANXIETY SOMATIC** 0 Absent — Psychological concomitants of anxiety, such as: 1 Mild — Gastro-intestinal - dry mouth, wind, indigestion, diarrhea, cramps, belching 2 Moderate — Cardio-vascular - palpitations, headaches 3 Severe — Respiratory - hyperventilation, sighing, GU-Urinary frequency 4 Incapacitating — Sweating	0	1	2	3	4
12	**SOMATIC SYMPTOMS GASTRO-INTESTINAL** 0 None 1 Loss of appetite but eating without staff encouragement. Heavy feeling in abdomen 2 Difficulty eating without staff urging. Requests or requires laxatives or medication for bowels or medication for G.I. symptoms.	0	1	2		
13	**SOMATIC SYMPTOMS GENERAL** 0 None 1 Heaviness in limbs, back or head. Backaches, headache, muscle aches. Loss of energy and fatigability. 2 Any clear-cut symptom rates 2	0	1	2		
14	**GENITAL SYMPTOMS** 0 Absent 1 Mild — Symptoms such as: Loss of libido, Menstrual disturbances 2 Severe	0	1	2		
15	**HYPOCHONDRIASIS** 0 Not present 1 Self absorption (bodily) 2 Preoccupation with health 3 Frequent complaints, requests for help, etc. 4 Hypochondrial Delusions	0	1	2	3	4
16	**LOSS OF WEIGHT** *RATING BY HISTORY:* 0 No weight loss 1 Probable weight loss associated with present illness 2 Definite (according to patient) weight loss	0	1	2		
17	**INSIGHT** 0 Acknowledges being depressed and ill 1 Acknowledges illness but attributes cause to bad food, climate, overwork, virus, need for rest, etc. 2 Denies being ill at all	0	1	2		

Clinician Signature: ______________________________

Figure C.7: Hamilton Depression Rating Scale (HAMD), page 2.

Name …...................................... Session.................... Date …..

POMS

Please rate from "0" = not at all to "4" = extremely, how the different adjectives represent your current mood state!

Friendly	0___1___2___3___4	Sluggish	0___1___2___3___4
Tense	0___1___2___3___4	Uneasy	0___1___2___3___4
Happy	0___1___2___3___4	Kindly	0___1___2___3___4
Angry	0___1___2___3___4	Lonely	0___1___2___3___4
Worn out	0___1___2___3___4	Miserable	0___1___2___3___4
Unhappy	0___1___2___3___4	Efficient	0___1___2___3___4
Confused	0___1___2___3___4	Bitter	0___1___2___3___4
Lively	0___1___2___3___4	Pleased	0___1___2___3___4
Unable to concentrate	0___1___2___3___4	Alert	0___1___2___3___4
Sorry for things done	0___1___2___3___4	Ready to fight	0___1___2___3___4
Shaky	0___1___2___3___4	Restless	0___1___2___3___4
Listless	0___1___2___3___4	Good-natured	0___1___2___3___4
Overjoyed	0___1___2___3___4	Gloomy	0___1___2___3___4
Peeved	0___1___2___3___4	Desperate	0___1___2___3___4
Agreeable	0___1___2___3___4	Rebellious	0___1___2___3___4
Sad	0___1___2___3___4	Nervous	0___1___2___3___4
Active	0___1___2___3___4	Helpless	0___1___2___3___4
On edge	0___1___2___3___4	Weary	0___1___2___3___4
Grouchy	0___1___2___3___4	Elated	0___1___2___3___4
Fatigued	0___1___2___3___4	Forgetful	0___1___2___3___4
Muddled	0___1___2___3___4	Deceived	0___1___2___3___4
Blue	0___1___2___3___4	Full of pep	0___1___2___3___4
Energetic	0___1___2___3___4	Warm-hearted	0___1___2___3___4
Spiteful	0___1___2___3___4	Carefree	0___1___2___3___4
Hopeless	0___1___2___3___4	Furious	0___1___2___3___4
Satisfied	0___1___2___3___4	Uncertain about things	0___1___2___3___4
Panicky	0___1___2___3___4	Worthless	0___1___2___3___4
Helpful	0___1___2___3___4	Anxious	0___1___2___3___4
Unworthy	0___1___2___3___4	Vigorous	0___1___2___3___4
Annoyed	0___1___2___3___4	Terrified	0___1___2___3___4
Cheerful	0___1___2___3___4	Good-tempered	0___1___2___3___4
Exhausted	0___1___2___3___4	Guilty	0___1___2___3___4
Resentful	0___1___2___3___4	Bushed	0___1___2___3___4
Forgiving	0___1___2___3___4	Bad-tempered	0___1___2___3___4
Discouraged	0___1___2___3___4	Refreshed	0___1___2___3___4
Relaxed	0___1___2___3___4	Bewildered	0___1___2___3___4

Figure C.8: Profile of mood states (POMS).