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Music-evoked emotions in schizophrenia

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ABSTRACT

Background/objectives: Previous studies have reported that people with schizophrenia have impaired musical abilities. Here we developed a simple music-based assay to assess patient's ability to associate a minor chord with sadness. We further characterize correlations between impaired musical responses and psychiatric symptoms.
Method: We exposed participants sequentially to two sets of sound stimuli, first a C-major progression and chord, and second a C-minor progression and chord. Participants were asked which stimulus they associated with sadness, the first set, the second set, or neither. The severity of psychiatric symptoms was assessed using the Positive and Negative Syndrome Scale (PANSS). Study participants were 29 patients diagnosed with schizophrenia and 29 healthy volunteers matched in age, gender and musical background.
Result: 37.9% (95% confidence interval [CI]:19.1–56.7) of patients with schizophrenia associated the minor chord set as sad, compared with 97.9% (95%CI: 89.5–103.6) of controls. Four patients were diagnosed with treatment-resistant schizophrenia, and all four failed to associate the minor chord with sadness. Patients who did not recognize minor chords as sad had significantly higher scores on all PANSS subscales.
Conclusions: A simple test allows music-evoked emotions to be assessed in schizophrenia patient, and may show potential relationships between music-evoked emotions and psychiatric symptoms.

1. Introduction

Among people with schizophrenia, functional and metabolic abnormalities in the limbic system have been widely reported. In studies of healthy humans, subjects associated major chords with happiness, minor chords with sadness, and dissonant chords with unpleasantness (Crowder, 1985). Music-induced emotional changes have been associated with hemodynamic changes in limbic/paralimbic structures, core brain areas associated with emotional processing (Blood and Zatorre, 2001). Lesion studies have shown that in particular, damage to the amygdala leads to impaired associations of music to either pleasurable or fearful emotions (Gosselin et al., 2005; Griffiths et al., 2004), an effect known as acquired amusia (Sarkamo et al., 2009). Dopaminergic activity in the ventral striatum has also been proposed to mediate pleasurable associations with music (Menon and Levitin, 2005; Salimpoor et al., 2011). Previous anthropologic investigations have found that music-evoked emotions are independent of listeners' cultural backgrounds, supporting the idea that they are derived from a relatively fundamental system of the central nervous network (Egermann et al., 2014; Fritz et al., 2009).

Among people with schizophrenia, functional and metabolic abnormalities in the limbic system have widely reported (White et al., 2008; Tamminga et al., 1992). Inefficient limbic activity is associated with cognitive impairments such as diminished affect discrimination and verbal memory deficit (Hempel et al., 2003; Suazo et al., 2013). These cognitive impairments are present in very early stages of schizophrenia (Albus et al., 2002), and persist throughout life (Hughes et al., 2003).

Consistent with altered limbic activity, several studies have reported that people with schizophrenia have impaired musical abilities (Hatada et al., 2014; Wen et al., 2014). This suggests that measurements of music-evoked emotions may be useful as a quick, non-invasive method to detect the presence or severity of cognitive changes that occur in schizophrenia, and may be useful for early diagnosis of the disease, and as a biomarker for treatment response. The Montreal Battery of Evaluation of Amusia (MBEA) is widely used to assess objective aspects of musical recognition (Peretz et al., 2003). However, the MBEA requires focused attention for >1 h, and is thus less reliable, in terms of accuracy and reproducibility, when applied to individuals with severe mental disorders.

In this paper, we describe a simple test for evaluating of music-evoked emotions. This test, referred to as the Harmony Test, makes it possible to identify changes that arise from mental disorders and sheds light on the relationship between evoked emotions and clinical features in schizophrenia.

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2. Method

2.1. Participants

We recruited participants hospitalized in Tokyo Metropolitan Matsuzawa Hospital who were: (A) diagnosed with schizophrenia according to the criteria of the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV); and (B) mentally stable enough to participate in a semi-structured interview for assessment by the Positive and Negative Syndrome Scale (PANSS) (Kay et al., 1987). The exclusion criteria were: (A) patients who had gross hearing impairment; (B) patients who were under psychomotor excitation; and (C) patients who could not or did not provide written consent. After excluding three potential participants because they refused to participate, 29 patients were eligible. All patients (10 men, 19 women; median age, 42.0 years; standard deviation [SD] = 18.6 years; age range, 16–75 years) had completed at least nine years of formal education. The median disease duration was 20.0 years. All patients were taking antipsychotic medications (median CP equivalent, 750 mg; SD = 608 mg; range 150–3056 mg). 29 volunteers matched for age, sex, and musical background were also recruited as a control group. Musical backgrounds were quantified using Grison's revised criteria (Grison, 1972) (changes from the original criteria are shown in supplemental data, Table 1). Informed consent was obtained from all participants before enrollment in the study, which was approved by the Ethics Committees of Tokyo Metropolitan Matsuzawa Hospital.

2.2. Stimuli

The experimental paradigm was designed by D.A. and consisted of two sets of sound stimuli that were synthesized using Musescore (https://musescore.org/) in piano timbre (Fig. 1, the .wav files are included in Supplemental data). Each stimulus set lasted for 4 s. The first set consisted of notes in the C Major chord, and consisted a progression of quarter notes, C, E, G, followed by a quarter rest, and then all three notes of the chord played together for a half note. The second stimulus set was identical to the first except that the E in both the progression and chord were replaced with E flat to produce a C minor progression and chord. The audio signal level in both sets was approximately −12 VU.

2.3. Procedures

First, each participant was assessed for severity of symptoms using the PANSS. The musical backgrounds of the participants were classified using Grison's criteria. Psychiatric history was gathered from medical records and family informants.

After the PANSS assessment, all participants were asked to answer the following questions. “Which chord sounds sad? Choose one of the following three: The first sound, the second sound, or neither (if you are not sure).” The major and minor chord stimuli were then presented with 2-second gaps in between using handy stereo IC recorder (ICD-PX440; Sony, Tokyo, Japan). Stimuli were presented once and were not repeated. Participants' answers were recorded, and they were then debriefed. The Harmony test consisted of the question, presentation of the sound stimuli, and recording of the answer. Each test battery took approximately 1 h to administer (about 50 min for PANSS assessment, 15 s for the Harmony Test, and 5 min for debriefing). All procedures took place in a consulting room in a psychiatric ward.

Table 1
Revised Grison's Criteira.

Levels of musical culture	
1	Showed no interest in music; did not care to listen to it or to sing.
2	Occasionally sang familiar melodies such as nursery rhymes and regional songs; sometimes listened to music on a wireless device.
3	Enjoyed singing and had a “repertoire” that he/she (originally “he”) maintained and augmented; was a critical listener of music on a wireless device; bought CDs (originally “gramophone recordings”) and listened to them frequently.
4	Played an instrument but was not trained in theory or sight-reading.
5	Played an instrument; fair sight-reading ability and general music knowledge.
6	Was an excellent musician on both the practical and theoretical levels.

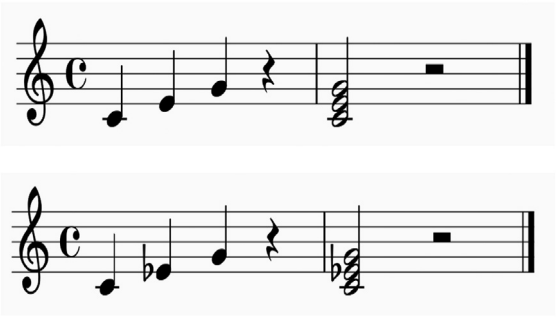

Fig. 1. Major chord and minor chord stimuli. Two files containing a recording of the sound stimuli are included in the Supplemental data. A) The Major chord stimulus set consists of a C Major arpeggio, C, E, G, and its chord. B) The minor chord stimulus set consists of C minor arpeggio, C, E flat, G, and its chord.

2.4. Statistical analysis

Statistical analyses were conducted using SPSS Statistics (ver. 23.0; IBM, Armonk, NY). The two-sided level of significance was set at 0.05. Means and medians with corresponding 95% confidence intervals (CIs) are given where appropriate.

3. Results

96.6% (95%CI: 89.5–103.6) of the controls identified the minor chord stimuli as sad. Therefore, we hereafter refer to the minor chord stimuli as the “correct” answer on the Harmony test, and other answers as “incorrect.” In contrast, only 37.9% (95%CI: 19.1–56.7) of the patients with schizophrenia chose the correct answer. The correct answer rate was significantly lower among patients with schizophrenia than among controls ($\chi^2 = 22.6$, df = 1, $p < 0.001$, $\varphi = 0.625$). The sensitivity of the Harmony test was 57.9%, and the specificity was 95.5%.

Among 18 schizophrenics who chose the incorrect answer, two chose major chord stimuli and the others selected “Neither.” No significant differences were seen in the schizophrenia group concerning Grison's criteria ($\chi^2 = 4.867$, df = 3, p = 0.182, Cramer's V = 0.29), and chlorpromazine equivalence (Mann-Whitney's U = 83.5, df = 18, p = 0.492, r = 0.13). The mean positive scale score was 18.6 (95%CI: 16.0–21.3, SD = 6.97), negative scale score was 28.7 (95%CI: 26.0–31.4, SD = 7.04), general psychopathology scale score was 46.4 (95%CI: 42.5–50.2, SD = 10.1), and total score was 93.7 (95%CI: 85.4–102.0, SD = 21.8).

Patients who chose the incorrect answer scored significantly higher in all scales compared with those who chose the correct answer (positive scale: Mann-Whitney's U = 55.5, p = 0.049, r = 0.36; negative scale: Mann-Whitney's U = 52.5, p = 0.035, r = 0.39; general psychopathology scale: Mann-Whitney's U = 27.0, p = 0.001, r = 0.60; total: Mann-Whitney's U = 36.5, p = 0.004, r = 0.52) (Fig. 2). Also, all four patients in our study who were diagnosed with treatment-resistant schizophrenia according to the criteria by the International Psychopharmacology Algorithm Project (IPAP) (IPAP, 2006), failed to associate the minor chord with sadness.

PANSS components with statistical significance were P1 Delusions; N4 Passive/apathetic social withdrawal; N5 Difficulty in abstract thinking; N7 stereotyped thinking; G8 uncooperativeness; G9 unusual thought content; G10 disorientation; G12 lack of judgment and insight;

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