Effect of Music on Emotions and Respiration

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Abstract: In the present study we investigated whether the emotional state induced by music can change respiratory rate (RR), tidal volume (VT), minute ventilation (VE), and end-tidal CO2 concentration (ETCO2). In a pioneering study investigating the effect of music on respiration, the music of Stockhausen and Chopin was used. In the present study, we examined the effects of the same musical stimuli used in that study on respiration. Each stimulus (Stockhausen, Chopin, and silence) was delivered for 30 s and each stimulus was presented five times in random order. Subjects reported feeling uncomfortable listening to Stockhausen’s music, but comfortable during Chopin’s music and silence. The respiratory response during exposure to Stockhausen’s music was rapid and shallow breathing, resulting in an increase in RR. Although the RR was decreased during silence and Chopin’s music by Chopin compared with that during Stockhausen’s music, there was no significant difference in RR in response to Chopin’s music and Stockhausen’s music. Although subjects reported feeling comfortable while listening to Chopin’s music, the decrease in RR was not significant. The lack of a significant decrease in RR in response to Chopin’s music may be due to a mixture of various emotions that may be interconnected to physiological responses, and this higher processing may be peculiar to humans.

Key words: music, chopin, stockhausen, emotions, respiration

Introduction

In recent years, music therapy has been increasingly used in various clinical settings as an alternative to medicine to reduce stress and/or pain1,2. However, there are no scientific studies that have investigated the mechanisms underlying the effects of music.

Research has suggested that alternative therapies can affect respiratory responses. Because respiration is closely linked to emotions, it can be an index of emotional state. To evaluate how subjects feel in response to stimuli, it is necessary to objectively measure subjective feelings3. Negative emotions, such as anxiety and fear, can increase respiratory rate

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(RR). Conversely, positive emotions, such as joy or happiness, can slow RR\(^4\). Following alternative therapies (e.g. dolphin-facilitated therapy), reduced anxiety and slower respiratory patterns have been observed\(^5\). Research has shown that viewing beautiful pictures of flower arrangements can also decrease RR\(^6\) and thus may be effective in reducing stress. Emotional changes during such activities have been reported, with slower breathing associated with positive emotions.

In the present study we investigated whether the emotional state induced by music can change RR, tidal volume (\(V_T\)), minute ventilation (\(V_E\)), and end-tidal CO\(_2\) concentration (ETCO\(_2\)). Two pieces of music composed by different artists were used to induce different emotional states in subjects. In a pioneering study investigating the effect of music on respiration, the music of Stockhausen and Chopin was used\(^7\). Stockhausen’s music produced a negative or unpleasant emotional state, whereas music by Chopin had a positive effect on emotion. In the present study, we examined the effects of the same musical stimuli on respiration.

**Methods**

**Subjects**

Seven healthy subjects (25.3 ± 5.5 years of age; three men and four women) participated in the present study. The subjects did not have any musical background in terms of playing an instrument or receiving musical education. In addition, all subjects usually listened to rock or jazz rather than classical music.

All subjects provided informed consent, and the study was approved by the Ethics Committee of Showa University School of Medicine.

**Physiological measurements**

Experiments were performed in a quiet room. Subjects sat on a chair wearing a facemask and earphones (Sony, Tokyo, Japan). An aeromonitor (AE280; Minato Medical Science, Osaka, Japan) was connected to the facemask to measure respiratory patterns. The respiratory monitor calculated RR, \(V_T\), \(V_E\), and ETCO\(_2\) on a breath-by-breath basis.

**Psychological measurements**

Subjects were asked to assess their feelings of pleasantness or unpleasantness using a visual analogue scale (VAS). The VAS comprised a 20-cm line placed horizontally on a page, with the far left side defined as ‘comfortable’ and the far right side defined as ‘uncomfortable’. Using a VAS to measure feelings in this type of setting has been shown to be more appropriate than using a categorical scale\(^8\).

**Musical stimuli**

We used three sound stimuli in the present study: silence; Chopin’s ‘Prelude No. 15’ (pia-
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no music; and Stockhausen’s ‘Mikrophonie’, in which a microphone is used as a musical instrument (noise music). Each sound stimulus was delivered for 30 s and was presented five times in random order. Sounds were presented binaurally via the earphones connected to a laptop computer (IBM, Tokyo, Japan). The intensity of the sound stimuli was set at 70 dB, a level perceived as comfortable for the subjects.

Data analysis

All statistical analyses were performed using a commercially available statistical package (SPSS Ver. 11.0; SPSS, Tokyo, Japan).

Comparisons of VAS scores for feelings produced by the three stimuli were analyzed by one-way analysis of variance (ANOVA). Greenhouse-Geisser adjustment of the degrees of freedom was applied to the ANOVA analysis to correct for violation of the assumption of sphericity. Post hoc testing was performed with Bonferroni’s test.

Comparisons of RR, V_T, V_E, and ETCO_2 between stimuli (silence, Chopin, and Stockhausen) were analyzed by ANOVA, with Greenhouse-Geisser adjustment of the degrees of freedom (to correct for violation of the assumption of sphericity) and Bonferroni’s post hoc test. P < 0.05 was considered significant.

Results

Typical examples of respiratory changes during exposure to each of the stimuli are shown in Fig. 1. Chopin’s music was associated with a slower breathing pattern, whereas Stockhausen’s music was associated with rapid and shallow breathing.

Fig. 2 shows VAS scores for the feelings reported by the seven subjects for each stimulus. The VAS score for Chopin’s music was significantly less than the scores for silence and Stockhausen’s music (P < 0.05). Conversely, the VAS score for Stockhausen’s music was significantly greater than that for silence and Chopin’s music (P < 0.05). These results indicate that Stockhausen’s music increased feelings of unpleasantness, whereas Chopin’s music decreased unpleasantness, with more comfort reported.

In terms of respiratory responses (Fig. 3), the feelings of unpleasantness caused by Stockhausen’s music increased RR and V_E compared with silence (P < 0.05). However, V_T remained unchanged (P = 0.3) and although there was a tendency for ETCO_2 to decrease during Stockhausen’s music, the difference failed to reach statistical significance (P = 0.08).

In the present study, we tested the effect of the sound stimulus on respiration five times and so it may have been possible that the stimuli had different effects between the first and last trials, as well as between trials. However, repeated-measures ANOVA confirmed that for each of the sound stimuli there were no significant differences in the effects of the stimulus on respiratory parameters between trials (all P > 0.05).
Discussion

In the present study we tested the effect of music on respiratory responses. For consistency with previous research\(^7\), we used music composed by Stockhausen and Chopin. The two musical stimuli produced different feelings in our subjects. Subjects reported feeling uncomfortable listening to Stockhausen’s music, but comfortable while listening to Chopin’s music. The respiratory response during exposure to Stockhausen’s music was rapid and shallow breathing, which resulted in an increase in RR. These results are consistent with those reported by Harrer\(^9\).

However, despite the fact that subjects felt comfortable while listening to Chopin’s music, RR was unchanged. That is, slower breathing patterns did not occur in subjects exposed to Chopin’s music. The possible reasons for this are discussed below.

Emotion and respiration

Research in respiratory psychophysiology has shown that various emotions alter breathing patterns. In particular, studies have focused on negative emotions, such as fear and anxiety, and the accompanying respiratory changes\(^4,10\). Fear and anxiety increase RR without
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Changing metabolic demand, indicating that the change in RR is due to activation of higher brain centers. On the contrary, an increase of \( V_T \) has been observed with an increase of metabolism\(^4\). The absence of increase of \( V_T \) during listening to Stockhausen’s music in this study supports that an increase of RR contributes to \( V_E \) increase because of the effect of factors such as attentions and emotions.

The dominant system affecting respiratory output is the limbic system, as opposed to brain stem regulation of respiration to maintain homeostasis. The amygdala (AMG), a structure within the limbic system, plays an important role in emotions\(^{11}\). Coactivation of the AMG by negative emotions suggests that the increased RR is part of the response related to defense mechanisms; that is, to increased alertness and arousal levels\(^{11}\). Thus, an increase in RR during exposure to Stockhausen’s music could be expected because negative emotion may activate the AMG, resulting in an increase in RR. In contrast, pleasant feelings decrease RR and increase \( V_T \)^{12}. Slow and deep breathing has been observed in

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**Fig. 3.** Mean ± SE respiratory rate (RR), tidal volume (\( V_T \)), minute ventilation (\( V_E \)), and end-tidal CO\(_2\) concentration (ETCO\(_2\)) in the seven subjects in response to the three sound stimuli, namely silence, Chopin’s music, and Stockhausen’s music. * \( P < 0.05 \).
individuals in a relaxed state, and a decrease in anxiety is associated with a decrease in RR\(^5,6\). In addition, even conscious control of slow breathing decreases anxiety\(^13\). Feelings of pleasantness and comfort are associated with slow and deep breathing, and breathing patterns can fluctuate between the extremes of unpleasant and pleasant emotions. In the present study, although subjects reported feeling more comfortable while listening to Chopin’s music, the decrease in RR was not significant compared with the RR in response to Stockhausen’s music. We speculate that two factors may have contributed to this outcome. The first factor is the method used to present the sound stimuli. The three stimuli used in the present study (Stockhausen, Chopin, and silence) were presented in random order, and all respiratory data were averaged for each stimulus. Thus, it may be difficult to detect differences in RR between silence and the music of Chopin. Responses to the music of Stockhausen (both VAS scores and RR) were quite high; in the case of both silence and Chopin’s music that followed, VAS scores and RR decreased. The second factor may be related to the effect of the character of the music on physiological responses. This theme is discussed in greater detail below.

Chopin’s music used as therapy

Music therapy in the clinical setting often uses instruments such as the piano or guitar and involves singing songs or listening to music. We have observed the effect of alternative therapy on respiration and found that positive emotions are associated with slowed breathing. In addition, we consistently observed as well as in this study that unconsciously changed slow breathing in positive emotions could keep homeostasis of the body, namely maintaining the ETCO\(_2\) level\(^5,6\). It could be important to note that the primary role for respiration is to keep homeostasis of the body. Relaxation by breathing change has to be met by the criteria specified by physiological and psychological factors.

In the present study, although RR was decreased during silence and Chopin’s music, there was no significant difference in RR between the three stimuli. Despite the lack of a significant decrease in RR, subjects reported feeling more comfortable after listening to Chopin.

The Chopin music we used in the present study was considered to be calm and relaxing music. However, other emotions, such as reverence or respect for this music, may have been involved in the subjects’ responses. These emotions may cause not only a sense of comfort, but also increased arousal and excitation. Relaxation may occur after strong activation of the limbic system with sympathetic activity\(^5,6\). It is hard to define what produces a ‘relaxed state’. However, we propose that a relaxed state or feeling comfortable may occur after increased arousal levels coactivated with positive emotions. The lack of a significant decrease in RR in response to Chopin’s music may be due to a mixture of various emotions that may be interconnected to physiological responses, and this higher processing may be peculiar to humans. Further research may distinguish more specific categories of feelings and elucidate different RRs related to these categories.
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