MUSIC LISTENING PRONENESS MODERATES THE EFFECTS OF EYES-OPEN VERSUS EYES-CLOSED MUSIC LISTENING ON EMOTION-RELATED SUBJECTIVES AND ELECTROCORTICAL RESPONSES

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ABSTRACT

Background. Listening to music often involves visual information that is not connected to the listened music (e.g., listening to music at home). Thus, it may be hypothesised that listening to music with eyes-closed may generate more focused listening experience than listening to music with eyes-open, because the incongruent visual information is attenuated.

Aims. The purpose of the present study was to compare the emotion-related responses to music listening with eyes-open and eyes-closed. It was expected that listening to music with eyes-closed would increase more electrocortical activation than listening with eyes-open, especially in frontal (mental focusing) and parietal regions (imagery).

Method. Measurements (i.e., self-report and brain activity) were taken during rest periods and during listening to music pieces that differed in terms of valence (i.e., positive-negative) and arousal (i.e., high and low). Participants rated their emotional mood instantly after each music piece using 5-point scales that consisted of 16 adjectives chosen from the emotion-circumplex.

Results. Music listening proneness moderated the effects on electrocortical activity. Listening to music with eyes-closed increased activation in all cortical regions. In addition, activation among low music listening proneness subjects increased in all sites during eyes-closed listening, but decreased in all sites during eyes-open listening. Thus the eyes-closed listening might have made music concentration easier for the subjects that have less experience in listening to music.

Conclusions. The present study gives no support for the frontal asymmetry theory of emotion. The results suggest that there might be many other than emotional variables (e.g., cognitive music processing) that moderate the effects of music on electrocortical activity. The future emotion research should try to differentiate the effects of non-emotional activities from emotional activity.

1. INTRODUCTION

Interest in human EEG has focused mainly on the reduction of alpha power (8-13 Hz), which has been associated with increased elecrocortical activation. A considerable body of research has found a relationship between emotions and frontal cortical activity. Some studies suggest that left and right frontal alpha activation is related to the experience of positive and negative emotions, respectively ("valence hypothesis"; e.g., Smith and Trainor, 2001), whereas other studies suggest that the right hemisphere processes both positive and negative information ("right hemisphere hypothesis"; e.g., Bryden, Ley, and Sugarman, 1982). However, though the importance of the functional asymmetry of the brain for the organization of emotions is commonly accepted, the relative contribution of the left and the right hemispheres is still under debate (e.g., Perez, 2001).

It has also been suggested that EEG asymmetries may be moderated by musical experience (e.g., Zatorre et al., 1996). However, studies dealing with music experience have typically compared music professionals with novices. It would be interesting to study the effects of less formal musical expertise (e.g., music listening proneness), because the emotional connotations to music do not necessarily depend on formal training.

Most of the results concerning the EEG asymmetry correlates of emotional states have been found using visual stimuli. However, the auditive information processing may have different kinds of characteristics. Therefore it would be also interesting to examine the effect of attenuating the visual information when listening to music.

2. AIMS

The purpose of the present study was to compare the emotion-related responses to music listening with eyes-open and eyes-closed. It was expected (hypothesis 1) that listening to music with eyes-closed would increase electrocortical activation especially in the frontal sites (more focused listening). It was also expected (hypothesis 2) that eyes-closed listening would increase imagery activity (i.e., more parietal activation) than listening music with eyes-open, because the visual stimuli that are not related to the music listened to are attenuated. Given that some recent studies suggest general dominance of the right hemisphere in music perception and emotional processes (e.g., Zatorre and Samson, 1988; Erhan et al, 1998), it was also expected (hypothesis 3) that the more music focused listening (eyes-closed listening) would lead to relatively higher right hemisphere activation - especially in subjects possessing more musical expertise (i.e., education or listening proneness). However, in regard to valence and arousal dimensions of the music pieces, it was expected (hypothesis 4) that there would be an increase in left-frontal activation during positive-music and in right-frontal activation during negative music, and in overall activation (both sites) during highly arousing music, as compared to the rest conditions (valence hypothesis: e.g., Smith and Trainor, 2001).

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3. METHODS

3.1. Subjects

Eighteen non-musician subjects with varying educational backgrounds participated in the study in return for two movie tickets. They were 10 Finnish males and 8 females ranging from 22 to 32 years of age (M = 26). Because EEG data was unusable for one subject, the number of participants included in the EEG analyses was 17.

3.2. Music

Four about 60-s long music excerpts differing in terms of valence (i.e., positive, negative) and arousal (i.e., high, low) were selected on a basis of ratings in a previous study (Kallinen and Ravaja, unpublished data). There were a priori high-arousal positive (i.e., Saint-Saen's "Carnival of Animals"), low-arousal positive (i.e., Bach's "Invention No.8"), high-arousal negative (Mussorgsky's "Night on the bare mountain"), and low-arousal negative ("Romance" from the Schumann's Symphony No.4) music pieces. Subjects listened to the group of 4 pieces in the same order twice. Half of the subjects listened to them first with eyes-closed and then eyes-open, whereas the other half listened to them first with eyes-open and then eyes-closed. The order of the four music pieces was based on a diagram-balanced Latin square.

3.3. Measures

Background factors such as age, gender, level of music education and music listening proneness (i.e., "How often do you listen to music"?) were assessed with a questionnaire.

Affective Ratings. According to some theorists (e.g., Larsen & Diener, 1992), the main affective dimensions are valence (ranging from positive to negative) and arousal (ranging from high to low), whereas according to other theorists (e.g., Watson, Wiese, Vaidya, and Tellegen, 1999), positive activation (PA; ranging from high PA to low PA) and negative activation (NA; ranging from high NA to low NA) are the basic dimensions of self-rated affect. I focused on these four dimensions using affect terms presented in Figure 1 [FIGURE1.GIF] to assess the different dimensions (there were two affect terms for each end of each dimension). Each of the items was rated on a 5-point scale, ranging from 1 (not at all) to 5 (very much), after the rest-periods and after each music piece. Scores for the four affective dimensions were calculated as follows: (a) valence: the sum of Positive items minus the sum of Negative items and (b) arousal: the sum of High Activation items minus the sum of Low Activation items, (c) PA: the sum of High PA items minus the sum of Low PA items and (d) NA: the sum of High NA items minus the sum of Low NA items. Thus, the maximum and minimum values on these dimensions ranged from 8 to –8.

EEG Recording and Data Reduction. EEG was recorded using the ECI-Electrocap system (Electro-Cap International, Eaton, OH). The cap electrodes were positioned according to the International 10/20-system. The EEG was recorded at eight scalp locations: left and right frontal (F3, F4), central (C3, C4), temporal (T7, T8), and parietal (P3, P4) regions. The electrodes were referred to vertex (Cz), and the ground electrode was located at the midforehead (AFz). Impedance at each electrode site was maintained below 5 KΩ. Eye movements (EOG) were also recorded to facilitate artefact scoring of the EEG. All data were acquired at a sampling rate of 500 Hz.

The data were partitioned into 2-s epochs and inspected for the presence of artifacts. All artifact-free EEG data were then analysed using the fast Fourier transform (FFT) technique, with a Hanning window of 2-s width and no overlap. Power estimates (mV^2) were derived from the FFT in the alpha (8-13 Hz) EEG band. The power spectral estimates for successive 2-s epochs were averaged across each condition (i.e., eyes-open rest, eyes-closed rest, and music samples [i.e. 2 x 4]). Mean spectral estimates for each condition were then natural log-transformed. Delta scores (i.e., eyes-closed music minus eyes-closed rest, and eyes-open music minus eyes-open rest) were calculated for each music piece and electrode site, given that eyes-closed and eyes-open conditions as such differ greatly in electrocortical activation patterns (e.g., there is less parietal activation during eyes-closed than during eyes-open).

3.4. Procedure

The subject was told that baselines shall be measured first, and then four music excerpts would be presented twice, which should be first listened with eyes closed (or eyes-open) and second with eyes-open (or eyes-closed). The subjects rated their mood using the affect terms after each piece. Music was presented using Harman-Kardon multimedia speakers with a comfortable sound level. The experiment was conducted in a dimly illuminated, electrically shielded laboratory room.

3.5. Data Analysis

All data were analysed by the General Linear Model (GLM) Repeated Measures procedure in SPSS, with three (rating analyses) or four (EEG cortical site analyses) within-subjects factors, i.e., valence (positive, negative), arousal (high, low), condition (eyes-closed, eyes-open) and hemisphere (left, right). Continuous independent variables (i.e., age, level of musical education, music listening proneness) were used, each in turn, as a covariate, while gender was a categorical independent variable. Significant interactions were graphed for participants receiving low (1 SD below the mean) and high (1 SD above the mean) scores on the moderator variable (e.g., music listening proneness).

4. RESULTS

Given the large number of analyses, only the main effects and two-way interactions at $p = .01$ or higher are presented and discussed.

4.1. Affect Ratings

The GLM Repeated Measures analysis revealed a significant main effects for (1) valence, $F(1,17) = 59.4$, $p < .001$, in predicting valence ratings, (2) valence, $F(1,17) = 11.60$, $p < .01$, and arousal, $F(1,17) = 50.62$, $p < .001$, in predicting arousal ratings, (3) valence, $F(1,17) = 13.31$, $p < .01$, and arousal, $F(1,17)$

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= 23.48, $p < .001$, in predicting PA, and (4) arousal, $F(1,17) = 59.55$, $p < .001$, in predicting NA ratings. The a priori positive music pieces prompted higher positive valence ratings than the a priori negative music pieces (Ms = 4.42 and –0.10). The a priori positive music pieces prompted higher arousal ratings than the a priori negative music pieces (Ms = 1.75 and 0.32), and the a priori high arousal music pieces prompted higher arousal ratings than the a priori low arousal music pieces (Ms = 2.64 and –0.58). The a priori positive and high arousal music prompted higher PA ratings than the a priori negative and low arousal music (for positive and negative music Ms = 2.82 and 0.82; for high and low arousal music Ms = 2.97 and 0.65). The a priori high arousal music prompted higher NA ratings than the a priori low arousal music (Ms = -1.24 and –4.26).

In addition, a significant Valence × Arousal interaction was revealed in predicting arousal ratings, $F(1,17) = 18.97$, $p < .001$, Valence × Condition interaction was found in predicting PA, $F(1,17) = 8.44$, $p = .010$, and Valence × Arousal interaction was found in predicting NA ratings, $F(1,17) = 35.19$, $p < .001$. The a priori high arousal music prompted higher arousal ratings especially for negative music (arousal ratings for negative music Ms = 2.89 and –2.25; arousal ratings for positive music Ms = 2.42 and 1.08, respectively). The eyes-closed listening prompted higher PA ratings than eyes open-listening for positive music (Ms = 3.19 and 2.42), whereas the eyes-open listening prompted higher PA ratings than eyes-closed listening for negative music (Ms = 1.06 and 0.58). In regard to positive music there was no major difference between high arousal and low arousal music (Ms = -2.80 and –3.70), whereas in regard to negative valence the high arousal music prompted higher NA ratings than low arousal music (Ms = 3.61 and –4.8).

4.2. Electroencephalography (alpha 8-13 Hz)

Frontal activation. The GLM Repeated Measures analysis revealed significant Condition × Music listening proneness, $F(1,15) = 19.55$, $p < .001$, and Hemisphere × Music listening proneness, $F(1,15) = 12.38$, $p < .01$, interactions in predicting frontal delta scores (i.e., log alpha power during music listening minus log alpha power during rest). The eyes-closed listening increased (delta scores decreased) but eyes-open listening decreased (delta scores increased) frontal activation among low music listening proneness subjects (for delta scores Ms = -0.19 and 0.17), whereas among high music listening proneness subjects both listening conditions increased, eyes-open more than eyes-closed, the frontal activation (for delta scores Ms = -0.08 and –0.01). In addition, as illustrated in figure 2 [FIGURE2.GIF], music listening increased left but decreased right frontal activation among low music listening proneness subjects, whereas music listening increased both left and right, and more right than left, among high music listening proneness subjects.

In this model (controlling for Music listening proneness) the Condition × Hemisphere interaction was also significant, $F(1,15) = 29.54$, $p < 001$, and there were main effects for condition, $F(1,15) = 22.00$, $p < .001$, and hemisphere, $F(1,15) = 11.87$, $p < .01$, in predicting frontal delta scores. As illustrated in figure 3 [FIGURE3.GIF], the eyes-closed listening increased but eyes-open listening decreased frontal overall activation. In regard to hemisphere asymmetry, it was noticed that the left activation increased more than the right activation during music listening (Ms = -0.04 and –0.03). The delta scores showed also that in eyes-closed listening the right activation increased (delta scores decreased) more than the left activation (Ms = -0.11 and –0.06), whereas in eyes-open listening the left activation increased (M = -0.07) but the right activation decreased (M = 0.05) as compared to resting conditions.

Parietal activation. In predicting parietal delta scores, a significant Condition × Music listening proneness interaction was found, $F(1,15) = 25.23$, $p < .001$. The parietal activation increased during eyes-closed music listening among both low and high music listening proneness subjects (for delta scores Ms = -0.13 and –0.15), whereas in eyes-open condition the parietal alpha increased among high music listening proneness (M = -0.03) but decreased among low music listening proneness (M = 0.71). In this model (controlling for music listening proneness) there was also a significant main effect for condition, $F(1,15) = 31.27$, $p < .001$. As illustrated in figure 4 [FIGURE4.GIF], parietal activation increased during eyes-closed music listening but decreased during eyes-open music listening as compared to rest conditions.

In addition, a significant Hemisphere × Musical education interaction was revealed, $F(1,14) = 9.33$, $p < .01$. Among the less musically educated, the parietal activation decreased in both hemispheres (for left and right delta scores Ms = 0.13 and 0.18), whereas among the higher musically educated in the left hemisphere parietal activation there was no difference (M = 0.03), whereas the parietal activation in the right hemisphere increased (M = -0.12).

Central activation. The GLM Repeated Measures analysis revealed a significant Condition × Hemisphere interaction in predicting central delta scores, $F(1,16) = 9.21$, $p < .01$. Eyes-closed music listening increased both left and right central activation, right more than left, whereas eyes-open listening decreased both left and right central activation, right more than left (for eyes-closed left and right central delta scores Ms = -0.05 and -0.11; for eyes-open left and right central delta scores Ms = 0.08 and 0.15).

In addition, a significant Condition × Music listening proneness interaction in predicting central delta scores was found, $F(1,15) = 20.70$), $p < .001$. Eyes-closed listening increased, but eyes-open decreased central activation among low music listening proneness (Ms = -0.15 and 0.34), whereas among high music listening proneness there was no difference between the two conditions (Ms = -0.03 and –0.04). In this model (controlling for music listening proneness) there was also a significant main effect for condition, $F(1,15) = 23.79$, $p < .001$. The eyes-closed listening increased central activation, whereas the eyes-open decreased central activation (Ms = -0.08 and 0.11). In addition, there was a main effect for music listening proneness in predicting central delta scores, $F(1,15) = 12.05$, $p < .01$. Music listening increased central activation among high music listening proneness subjects (M = -0.04), but decreased central activation among low music listening proneness (M = 0.09).

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Temporal activation. In predicting temporal activation, a significant Condition × Music listening proneness interaction was revealed, $\underline{F}(1,15) = 22.60$, $\underline{p} < .001$. Eyes-closed listening increased, but eyes-open listening decreased temporal activation among the low music listening proneness (Ms = -0.18 and 0.36), whereas among the high music listening proneness there was no difference between the two conditions (Ms = -0.08 and –0.09). In this model (controlling the music listening proneness) there was also a significant Condition × Hemisphere interaction, $\underline{F}(1,15) = 20.19$, $\underline{p} < .001$, and a main effect for condition, $\underline{F}(1,15) = 27.22$, $\underline{p} < .001$. Eyes-closed listening increased temporal activation, but eyes-open listening decreased it (Ms = -0.12 and 0.10). The eyes-closed listening increased and eyes-open listening decreased especially right hemisphere activation (for eyes-closed left and right temporal delta scores Ms = -0.08 and -0.15; for eyes-open left and right central delta scores Ms = 0.07 and 0.13).

In addition, a significant main effect for Music listening proneness was found in predicting temporal activation, $\underline{F}(1,15) = 17.16$, $\underline{p} = .001$. Music listening increased temporal activation among high music listening proneness subjects (M = -0.08), but decreased temporal activation among low music listening proneness (M = 0.09).

5. CONCLUSIONS

As summarised in the figure 5 [FIGURE5.GIF], listening to music with eyes-closed increased, whereas listening to music with eyes-open decreased, cortical activation in all regions when the effect of music listening proneness was controlled. Thus, the results support hypothesis 1, which stated that eyes-closed music listening would increase electrocortical activation (focused listening experience), because the visual information that is not related to the listened music is attenuated. The results support also hypothesis 2, which stated that parietal activation increase. However, the reason for increased parietal activation may be due to the increase in overall activation (all sites) as well as due to the increased mental imagery.

The results suggest also right hemisphere dominance in music processing (hypothesis 3). The eyes-closed music listening increased, and eyes-open listening decreased, especially the right hemisphere activation in frontal, central and temporal sites. It was also noticed that among the higher musically educated subjects especially the right parietal activation, and among the high music listening proneness the right frontal activation increased more than left hemisphere activation in those sites. Thus it seemed, as also expected in hypothesis 3, that the music listening prompted more activation in the right hemisphere especially among the subjects possessing higher musical expertise.

It was also found that music listening increased activation in all sites and conditions among high music listening proneness subjects. However, among low music listening proneness the overall (both hemispheres) activation in central and temporal regions decreased, and left frontal activation increased. In addition, it was found that activation among low music listening proneness subjects increased in all sites during eyes-closed listening, but decreased in all sites during eyes-open listening. Thus the eyes-closed listening might have made music concentration easier for the subjects that have less experience in listening to music.

The results gave no support for the valence theory, according to which frontal asymmetry indexes positive or negative mood (hypothesis 4). There was not relatively more left frontal activation during positive music or right frontal activation during negative music, even though the differences in self-reports were highly significant. The results suggest that there might be also many other variables (e.g., cognitive music processing) that moderate the effects of music on cortical activity. For example, negative valenced music (e.g., in minor mode) might include more complex harmony than positively valenced music (major mode), and thus involve more cognitive processing. The future emotion research should try to differentiate the emotional activity from other kinds of activities.

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