The Effect of Music Harmonics and Level of Expertise on Aesthetic Judgment of Music: An ERP Study

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ABSTRACT

The aim of our study was to investigate the influence of harmonic violation on aesthetic judgment of music in music experts and naives. Two groups took part in experiment: music experts (14 subjects, 8 female) and naives (13 subjects, 7 female). Music experts were graduates and undergraduates of music school, played musical instruments or educated in the field of singing from an average of 9.79 years. The group of naive did not have any special musical education besides normal school education. Participants were asked to listen the stimuli and judge whether each of them sounds beautiful (when the beauty judgment task was required) or correct (when the correctness judgment task was required). We used excerpts of five Bach's chorales as a stimuli. Each of the excerpt was modified in order to obtain three versions of one excerpt differing only in one chord. This chord ('target') sounded: congruous, ambiguous or incongruous to harmonic context of the piece. Several differences in event-related potential (ERP) parameters were observed in aesthetic processing of music. The findings of our study showed that an affective aspect of music processing is reflected by LPP – Late Positive Potential. This effect differ in respect of degree of harmonic violation indicating that the incongruous chords enhanced the higher amplitudes. What is more, there was significant difference between two judgments (aesthetic or correctness) showing that the LPP is sensitive on task manipulation. Higher amplitudes for beauty judgment task than for correctness judgment task indicted that aesthetic evaluation is perceived as an affective task. However, our study did not confirm the influence of music expertise on affective aspect of music aesthetic processing. All our results are discussed in the context of previous studies.

Keywords: music aesthetic, music expertise, ERP, harmonic violation, late positive potential

INTRODUCTION

Meyer (1956) proposed the hypothesis that listening to music elicits expectations about what will happen next in musical sequence. Fulfillment of these expectations elicits feeling of relaxation but their violation elicits the feeling of tension. The stronger the harmonic violation is, the higher evaluation of tension, overall subjective emotionality and electrodermal response of listener (Steinbeis, Koelsch and Sloboda , 2006).

Electrophysiological measure of affective music processing is late positive potential (LPP) (Müller, Hofel, Brattico and Jacobsen, 2010). Current studies pointed that the size of LPP amplitudes is affected by emotional intensity of visual stimuli (Cuthbert, Schupp, Bradley, Birbaumer, and Lang, 1999; Foti, Hajcak and Dien, 2009; Schupp, Junghöfer, Weike and Hamm, 2004). The influence of emotional intensity of musical stimuli on LPP has not been tested. It is worth checking if the amplitude of LPP varies depending on the level of harmonic violation, similarly to measures used in previous studies (Steinbeis et al., 2006).

LPP effect is also influenced by the type of the task (Foti and Hajcak, 2008; Hajcak, Moser, and Simons, 2006; Hajcak and Nieuwenhuis, 2006; Moser, Hajcak, Bukay, Simons, 2006) and the level of music expertise (Müller et al., 2010). Müller et al. (2010) examined if the LPP amplitude differs depending on the level of musical expertise of participants and type of task while listening to music. They found a larger amplitude LPP while performing the task of a beautiful chord sequence rather than the task of evaluating correctness of musical stimuli but only in group of naives. Amplitude of LPP was similar for both task in group of experts. In questionnaire study Istók et al. (2009) showed that laymen strongly associated music with the aesthetic evaluation of mood and affective regulation than music experts. Results of these studies show differences between music experts and naives with respect to affective aspect of music aesthetic.

Müller et al. (2010) presented simple music sequences to participants. In interpreting results of no differences between two tasks for LPP in group of experts, they suggest that the simple material could be too transparent and obvious for this group. If the experts apply the same analytical operations when assessing beauty, which were used by them during the assessment of the correctness, the lack of differences in the amplitude of the LPP in this group becomes understandable. It seems reasonable, therefore, to check whether the use of more complex stimuli affect the size of the potential of LPP in the group of experts.

To sum up, the present study verified the hypothesis that chords violating musical harmony induced larger LPP effect than chords with no violation. As the LPP reflects the emotional arousal in response to a stimulus, it can be expected that the more intense emotional reaction (expressed in stronger violation of harmony), the greater the amplitude of this potential. Secondly, we expected differences in the size of the LPP potential for two tasks (beauty judgment task and correctness judgment task) for laypersons and music experts.

METHOD

Participants

27 subjects took part in the experiment. They were divided into two group: 14 of them were in group of experts (8 female, 3 left-handed, average age = 20,5 years, SD=1,56) and 13 were in group of naives (7 female, 1 left-handed, average age = 22,85 years, SD=1,34). Group of experts composed of the subjects who played a musical instrument or educated in the field of singing from an average 9.79 years (SD = 3.62). Average time spent on practicing skills or singing was 10 hours per week (SD = 5.87). These individuals were graduates or students of music schools. Experts knew the basics of music theory and were able to play at least one instrument or sing professionally. Group of naives consisted of subjects who had never learned how to play musical instruments and did not receive singing lessons. Subjects in this group attended music classes only during primary education.

Stimuli

The stimuli consisted of excerpts of 5 chorales composed by J.S. Bach (Riemenschneider, 1941). Fragments of the same chorales were used in the study by Steinbeis et al. (2006). Participants were presented excerpts of chorales in their original form and slightly modified in two ways within the chosen cadence. Point of cadence (the chord) with the modification has been named "the target." The target was always 9 to 14 chords after the start of stimuli (in order to build a musical expectation by subject) and 5 to 14 chords before the end of stimuli. Thanks to this procedure the target was not always in the same place; stimuli were less predictable and complex. Subject was not able to predict where the target is, listened to the whole piece and not streamlined to wait for that chord (the target).

Two alternative versions of target were composed for every excerpt of chorales. In that way 3 different versions of one excerpt (differed only in the target) were obtained:

- congruous stimuli (with expected chord, harmonically corrected tonic chord)
- ambiguous stimuli (with unexpected chord, original Bach's compositions)
- incongruous stimuli (with very unexpected chord, harmonically incongruous Neapolitan chord).

By modification of five chorales, 15 stimuli were obtained. For congruous stimuli we tonic chord was used in place of the target. For incongruous stimuli Neapolitan chord was always used. In order to obtain target with similar time duration like in study by Müller et al. (2010), the rate of excerpts were changed. It was change in the way that the target with pause after the target took at least 1100ms. In order to preserve the natural character of the stimuli no rigid limits of target's length were used. Stimuli lasted from 13 to 21 s. Stimuli were 32-bit recordings in the WAVE format.

PROCEDURE

Participants were asked to listen to the excerpt of chorale and then decided whether this excerpt sounded correct/incorrect (when correctness judgment task was required) or beautiful/not beautiful (when beauty judgment task was required). Subjects answered by pressing one of bottoms (Yes/No) on the pad. Experiment consisted of two parts: practise part and experiment. The practise part was introduced in order to get participants tested with the procedure of the experiment. It had got the same structure as the experiment. In practise part there were used Bach's chorales but different than this used in main experiment. After the practise part participants were asked if everything is clear for them. Then the experiment began.

A fixation point appeared in the screen for 800 ms. The fixation point disappeared and the question ('Beautiful?'/'Correct?') was shown for 1200 ms. The question disappeared and the fixation point was shown until the end of the stimulus. 800 ms after the onset of the fixation point, the stimulus was presented. After the end of stimulus, there was a pause lasting for 200ms. Then on the screen, "Yes/No" board appeared. This board disappeared when participant pressed the button to answer. Then the same procedure started for next stimuli. This procedure has been derived from studies Müller et al. (2010). The only change relates to the introduction of the board with the words "Yes" and "No". The introduction of this board was to identify participants when they have to answer. Every stimuli was presented 12 times (6 for correctness judgment task and 6 for beauty judgment task). All in all, the study included 180 presentations. In order to reduce the tiredness of participants, stimuli were presented in 6 blocks (30 stimuli in each block). After the first, third and fifth block there were 15 s break. After the second and fourth block impedance was measured and alignment of the cap and conductivity of electrodes were improved. The sequence of stimuli in the entire experiment was randomized according to the following condition: a maximum of 3 stimuli of a given task (beauty or correctness judgment task) and stimulus category (congruous, ambiguous, incongruous stimuli) in sequence.

After the experiment, participants were asked to complete the survey about their musical training and level of expertise. The experiment, including the practise part and the assumption of a cap and impedance measurement, took about 1 hour 50 minutes.

Apparatus and electrophysiological recordings

The study used a set of EEG GES 300 from EGI Geodesic equipped Net Amps 300 with a sampling frequency of 50 to 1000 Hz and a 64-channel HydroCell GSN cap. Recording took place in the Net Station program version 4.4. The experiment was presented in the E - Prime 2.0 Professional package synchronizing E-Prime Extension for Net Station. The study used the Dell monitor with a diagonal 17 "at a distance of 60 cm from the subject, with resolution of 1280 by 1024 pixels, and the Yamaha HS-50M loudspeaker. Participants answered with two buttons on the Subject Response Pad by Geodesic.

Data analyses

Data were recorded on 64-channel set EEG GES 300 maintaining the resistance of each electrode at 50 kΩ and the sampling frequency of 250 Hz. In order to control the ocular artefacts data from EOG were recorded. Recording of EEG activity took place in the Net Station in version 4.4. Data analysis was performed in MATLAB version 7.9.0 (package EEGLAB version 12.0.2.0b).The first step of analysis was filtration of data (critical high-pass frequency of 0.1 Hz, and critical low-pass frequency of 20 Hz). Then, the data were segmented into equal sections lasting 1200ms (100ms baseline before the presentation and 1100ms since the start of the presentation of the target with correction 5ms at the actual moment of exposure). The Independent Components Analysis (ICA) were conducted in order to remove artefacts from eye movement and muscle. Time windows were chosen after the inspection of difference waves. The repeated-measure ANOVA was conducted for every time window with factors: Chord Type (congruous, ambiguous, incongruous),Task (Beauty/Correctness judgment task), Side (Right[F4, C4, P4, O2], Middle[FZ, CZ, PZ, OZ], Left F3, C3, P3, O1]), Area (F-line [F3, FZ, F4], C-line [C3, CZ, C4], P-line [P3, PZ, P4], O-line[O1,OZ,O2]) and Group (Laypersons, Experts). Only significant effects were reported in detail. Error percentages reflecting Greenhouse-Geisser (G-G) corrected degrees of freedom and G-G epsilon (ε) values were reported.

RESULTS

LPP for type of chord

In order to check differences in brain activity for types of chords, the time window 600-1100ms was chosen. Repeated-measure ANOVA (Group, Chord Type, Side, Area) showed a significant main effect of factor Chord Type (F (2,50) = 11.64 p > 0.001 eta^2 = 0.32). The highest mean amplitude was 0.41 µV for incongruous chords. Mean amplitude for congruous chords was 0.25 µV and for ambiguous 0.07 µV. Additionally, there was main effect of factor Area (F (3,75) = 25.11 p > .001 eta^2 = 0.5 ε = 0.76) and interaction effects for factors Chord Type and Area (F (6,150) = 8.32 p > 0.001 eta^2 = 0.25), Side and Area (F (6,150) = 14.55 p > .001 eta^2 = 3.7 ε = 0.31) and Chord Type, Side and Area (F (12,300) = 11.01 p > .001 eta^2 = 0.21 ε = 0.29). These effects showed that the highest positive amplitudes were located in parietal and central areas. In the parietal area differences between all types of chords were statistically significant: the average amplitude were respectively: 1.83 uV for incongruous chords, 0.39 uV for ambiguous chords and 1.19 uV for congruous chords.

LPP for type of task

For LPP analysis of differences between two tasks, 700-1100ms after the begin of the target time window were chosen. In repeated-measures ANOVA (Group, Task, Side, Area) there was no significant main effects for factor: Task (F (1,25) = 0.32 p > .05 eta^2 = 0.013) and Group (F (1,25) = 0.49 p > .05 eta^2 = 0.02). Analysis showed significant main effect of factor: Area (F (3,75) = 18.80 p < .001 eta^2 = 0.43 ε = 0.52). The highest positive amplitudes were seen in occipital locations (1.02 µV). Repeated - measure ANOVA was conducted only for posterior locations. The main effect of factor Task was significant (F (1,25) = 4.64 p < .05 eta^2 = 0.16). Higher amplitudes was seen for beauty judgment task (0.89µV) than for correctness judgment task (0.63 µV). Main effect for factor Area was also significant indicating higher amplitudes in parietal areas (1.02µV) than occipital locations (0.49µV) (F (1,25) = 11.60 p < .05 eta^2 = 0.32). There was also significant interaction effect for factors: Side and Area (F (2,50) = 5.83 p < .05 eta^2 = 0.19). Significant differences between left side (0.64 µV) and middle (1.27 µV) were seen in parietal area.

DISCUSSION

Chords with strong violation of harmonic adequacy caused greater LPP effect than ambiguous and congruous chords which indicates their strong emotional character. LPP can be a measure reflecting emotional arousal in response to strong violation of harmony in music. It means that incongruous chords (in this case Neapolitan chords) are regarded by the subjects as intense stimuli. For that reason amplitude for incongruous chords is the highest. This is consistent with studies showing increase in the amplitude of the LPP in relation to such visual stimuli excitatory (Cuthbert et al., 1999; Foti et al., 2009; Schupp, Junghöfer et al., 2004). Potential LPP, similarly to measures used in previous studies (Steinbeis et al., 2006), can be sensitive to strong violation of musical harmony.

Interestingly, chords with ambiguous harmonic violation had got smaller amplitudes than both incongruous and congruous chords. Ambiguous chords were original compositions whereas congruous and incongruous chords were modification created for the study. One explanation of this result is that original composition could not elicit strong arousal in listeners because of their real character. The composition is made in the way that despite its ambiguous harmonic accuracy it is more emotionally "digestible" than a modification in accordance with the harmonic rules. This effect can show that listeners are able to accept nuance appearing in the sequence in respect of the affective aspect of music processing, where they are naturally introduced by the composer.

The higher amplitude LPP for beauty judgement task compared to correctness judgement task was observed. This results are consistent with previous studies by Hajcak et al. (2006) indicating the higher amplitude of the LPP for affective judgment task compared to non-affective judgment task. Aesthetic evaluation is the task of the stronger affective character than evaluation of the accuracy of the music piece. In addition, the differences between tasks were observed in both groups. This means that the complex stimuli are capable of eliciting an affective response for beauty judgment not only for naives but also for music experts. The results of both our study and the study by Müller et al. (2010) suggest that the complexity of musical stimuli can influence the affective aspect of aesthetic evaluation for music experts, as reflected by the LPP effect occurring at the complex, and absent in the simple musical stimuli. This conclusion, however, requires further research.

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