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Neuroscience Letters 268 (1999) 21–24

Neuroscience Letters

Music effects on event-related potentials of humans on the basis of cultural environment

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Received 17 March 1999; received in revised form 7 April 1999; accepted 14 April 1999

Abstract

Auditory oddball responses were recorded from Turkish subjects in a silent environment or superimposed on white noise, or music played with violoncello or a similar music played with ney, a reed flute frequently listened by the Turkish population. P3 amplitudes with ney music in the background were significantly larger than both the white noise and violoncello backgrounds. The topography of the P3 response changed significantly between the ney and silent background conditions, indicating a relatively higher participation of frontal areas during hearing ney. Our results showed that hearing music of a familiar style increases the allocation of attentional resources during memory updating processes which is supposed to determine the P3 amplitude, and therefore showed the effects of cultural environment on the cognitive processes.

Keywords: Music; Event-related potentials; P300; Cognitive processes; Cultural effects

Effects of music on human psyche have long been known, and music effects on brain electrophysiology have been reported in a number of studies [1,3,9].

It has been shown that different patterns of event-related potential (ERP) asymmetries obtained with verbal vs. musical stimuli are not primarily a function of differences in the physical properties of the stimuli, but a function of endogenous factors such as the subject's cognitive approach to the processing of the stimuli. This finding suggests that endogenous factors play a significant role in differential hemispheric functioning and that the ERP technique employed is a sensitive index of changes in electrophysiological activity associated with these endogenous factors [11].

There is no doubt that one of the most important endogenous factors, which differ among the people, has its source in different socio-cultural environments. In this study, we hypothesized that the psychological effects of music changes in different cultural environments which could be measured by ERP.

For this purpose, auditory oddball responses obtained in a silent environment, on the background of white noise, music played with ney, which is frequently listened to by the Turkish population, and music played with violoncello had been compared. Ney is a reed flute played especially in Mevlevi (a sufi order) music. According to the sources of Turkish history of medicine, ney was one of the musical instruments used to treat psychiatric patients. To decrease the physical differences between both music backgrounds, solo performances of the two instruments with similar timbres had been chosen.

An auditory oddball paradigm with 1000 and 2000 Hz tones of 50 ms duration (R/F time = 10 ms) was applied under four different background conditions. The probability of 2000 Hz tones was 0.2. The stimuli were presented either in a silent environment or superimposed on white noise, on violoncello improvisations of David Darling or on ney improvisations of Sadreddin Özçimi.

The intensity of stimuli was 80 dB, whereas those of the background sounds were 60 dB above the hearing threshold.

Ten musically naive subjects (age: minimum 26 – maximum 35; mean: 31.6; sex: six males, four females) were instructed to detect the rare stimuli (2000 Hz) by the extension of the right index finger. The subjects were all from the same cultural background: Turkish, academic staff from the

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0304-3940/99/$ - see front matter
PII: S0304-3940(99)00372-9

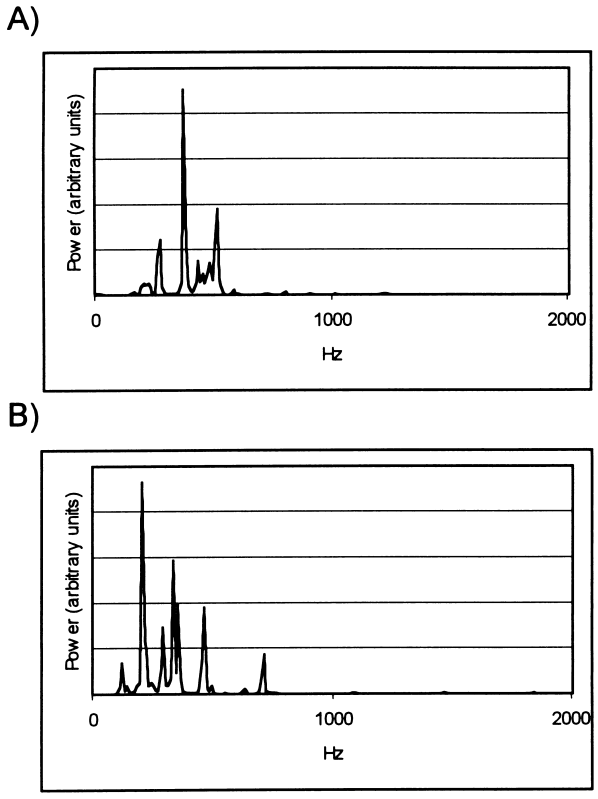

Fig. 1. Power spectra of musical pieces played with ney (A) and violoncello (B). The spectra are computed by averaging 150 epochs of 250 ms segments of each type of music. The coordinate scale shows the power (square of intensity) of the frequency components in arbitrary units. Only powers of the frequencies between 0 and 2000 Hz are shown, because main signal energies were located around 500 Hz.

University of Istanbul, from families of middle-class origin, and have been raised in a uniform music medium during the state monopoly on the radio and television broadcasting, which only changed in the 1990s. During their lifetime, they all listened to ney music from these sources frequently. We considered the subjects as music-naive on the basis of information given by them. ERPs were recorded from Oz, O1, O2, Pz, P3, P4, Cz, C3, C4, T3, T4, Fz, F3, F4, Fp1 and Fp2 sites according to the 10/20 system referenced to the linked earlobes.

The latencies and amplitudes of four peaks (N1, P2, N2 and P3) were measured. The mean amplitudes of the frontal, central and parietal responses were calculated and used for statistical analyses to decrease the degrees of freedom, and to reduce the possibility of false positivities in MANOVA. The lateralization effect was further analyzed by grouping and computing the means of left, midline and right electrode locations.

The results were tested by a MANOVA design for repeated measures with two factors, background sound (four levels: silence, white noise, violoncello, ney) and lead (three levels: parietal, central, frontal) or lateralization (three levels: left, midline, right). Greenhouse–Geisser correction was applied to MANOVA results.

Fig. 1 shows the power spectra of both the musical pieces played with ney and violoncello. The main powers of the two sounds are similarly concentrated around 500 Hz, which shows the similarity of the physical characteristics of both musical pieces.

Fig. 2 shows the grand averages of responses obtained from F3, Fz, F4, C3, Cz, C4, P3, Pz and P4 leads. The white noise and violoncello music induced amplitude decreases of all wave components compared with the silent condition, whereas the response amplitudes during ney music were similar to those of the silent condition. Whereas the ERP amplitudes were affected by the different auditory backgrounds, the reaction times did not change significantly among conditions.

Statistical results showed no significant changes in the latencies of the ERP waves among four conditions. No significant effect could also be obtained for the amplitudes of the N1, P2 and N2 waves beyond an overall lead effect for the N1 and N2 waves showing a typical centro-frontal topography (N1 lead: $F = 68.707$, $P < 0.001$; N2 lead: $F = 6.689$, $P < 0.03$).

However, effects of the background sounds on the P3 amplitudes were significant (background sound: $F = 5.121$, $P < 0.05$). The typical centro-parietal topography of the P3 was also obtained (lead: $F = 5.558$, $P < 0.05$) (Fig. 2).

The within-subjects contrasts indicated that the P3 amplitude did not differ significantly between ney music and silent background, but the amplitudes of the responses with ney music in the background were significantly larger compared with both white noise and violoncello backgrounds ($P < 0.05$). Furthermore, the topography of the P3 response changed significantly between the ney and silence conditions, indicating a relatively higher participation of frontal areas during hearing ney (background sound $\times$ lead: $F = 14.456$, $P < 0.005$) (Fig. 2).

No significant lateralization effect was obtained for any of the variables.

This study shows that music played with ney and violoncello have different effects on the electrophysiological parameters of Turkish subjects.

The smaller amplitudes of P300 waves obtained with white noise and violoncello music in the background compared to the silence condition could be explained by the relative decrease of the stimulus intensity due to the steady sounds of 60 dB in the background, generating a masking effect. Considering this physical effect, the white noise condition seems to be a better control for the two conditions with violoncello and ney music of the same mean intensity in the background.

The comparison of the responses recorded on ney and violoncello backgrounds with the responses recorded with white noise background showed that ney music increases the P3 amplitude significantly in Turkish subjects, whereas

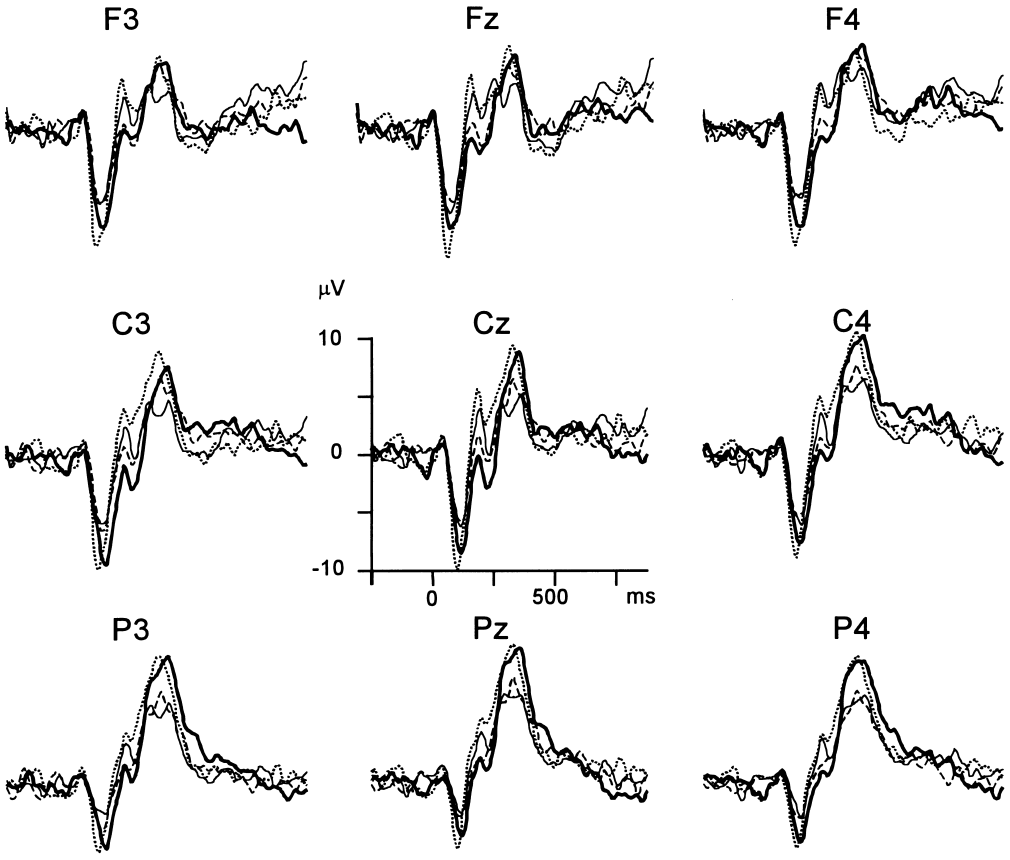

Fig. 2. The grand averages of oddball target responses of 10 subjects recorded on a silent background (dotted line) and on the backgrounds of white noise (thin line), music played with violoncello (dashed line) and music played with ney (thick line).

music played with violoncello did not change the P3 significantly.

On the basis of the increase of the P3 amplitude, which in general is interpreted as the reflection of selective attention and memory updating process [7], we conclude that ney music has a positive effect on these cognitive processes, whereas music played with violoncello does not. The relative increase of the frontal contribution to P3 with the effect of ney music might be considered a further finding supporting this viewpoint. These findings also replicate the findings of other authors with regard to the music effect on information processing [6].

One may argue that these results might be related to the arousal level of the subjects which could be affected by the type of music (familiar–unfamiliar). Neither the findings of this study showed any electrophysiological parameter indicating the difference in the level of arousal of the subjects, nor the processing-capacity influenced the arousal level factors as was indicated by different studies [5].

Although there is no consensus regarding to whether the effect of music is independent of its physical characteristics, we are cautious because of some findings that suggest possible relationships between the cognitive effects and physical characteristics of the music [2]. Then, as it is shown in the results, we checked the physical characteristics and found both of the instruments very similar.

Basically, our findings suggest that transcultural study designs are needed to overcome the confounding factors emanating from the cultural environment of population. Otherwise, it seems that it is not possible to grasp the precise meaning of the data obtained by the studies on music effects on the electrophysiological parameters.

Above all, this study suggests that music could be used either as a cognitive enhancer for certain psychiatric patients, such as the ones suffering from dementia, or as a supportive tool for certain psychotherapeutic interventions, such as cognitive psychotherapy. However, in order to reach this aim, it seems that one is obliged to take the cultural environment of the patient into account. This approach has been supported also by another study [10].

This study clearly shows that the therapeutic value of music is not only related to its calming effect, as was claimed by some authors. These authors claim that the relaxing effect of music reduces agitated behaviors among patients with severe cognitive impairment [4]. However, although our subjects found the music of both instruments calming, the effects of the two types of music on information processing capacity differed significantly.

As it is said by Rubin, Rahhal and Poon ‘things learned in

early adulthood are remembered best.' The authors nicely showed that for older adults, the period from 10 to 30 years of age produces recall of the most autobiographical, the most vivid, and the most important memories [8].

This work is supported by The Research Fund of the University of Istanbul. Project No.: 1132/010598.

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