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PROFESSIONAL MUSICIANS LISTEN DIFFERENTLY TO MUSIC

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Abstract—*Introduction:* Experience-based adaptation of emotional responses is an important faculty for cognitive and emotional functioning. Professional musicians represent an ideal model in which to elicit experience-driven changes in the emotional processing domain. The changes of the central representation of emotional arousal due to musical expertise are still largely unknown. The aim of the present study was to investigate the electroencephalogram (EEG) correlates of experience-driven changes in the domain of emotional arousal. Therefore, the differences in perceived (subjective arousal via ratings) and physiologically measured (EEG) arousal between amateur and professional musicians were examined. *Procedure:* A total of 15 professional and 19 amateur musicians listened to the first movement of Ludwig van Beethoven's 5th symphony (duration = ~7.4 min), during which a continuous 76-channel EEG was recorded. In a second session, the participants evaluated their emotional arousal during listening. In a tonic analysis, we examined the average EEG data over the time course of the music piece. For a phasic analysis, a fast Fourier transform was performed and covariance maps of spectral power were computed in association with the subjective arousal ratings. *Results:* The subjective arousal ratings of the professional musicians were more consistent than those of the amateur musicians. In the tonic EEG analysis, a mid-frontal theta activity was observed in the professionals. In the phasic EEG, the professionals exhibited an increase of posterior alpha, central delta, and beta rhythm during high arousal. *Discussion:* Professionals exhibited different and/or more intense patterns of emotional activation when they listened to the music. The results of the present study underscore the impact of music experience on emotional reactions.

Key words: music, EEG, neuroplasticity, emotion, arousal.

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Abbreviations: ACC, anterior cingulate cortex; BOLD, blood-oxygen-level dependent; EEG, electroencephalogram; SPL, sound pressure level; TANCOVA, topographic analysis of covariance; TANOVA, topographic analysis of variance.

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INTRODUCTION

In recent years, the exploration of professional musicians has been shown to provide excellent access for investigating the influence of musical experience on emotional reactions (James et al., 2008). Further, the underlying functional (Ott et al., 2011; Elmer et al., 2012) and structural (Jäncke, 2009; Moreno et al., 2009; Münte et al., 2002) changes may be well explored within professional musicians. Since alteration of emotional reaction due to musical expertise is not only restricted to musical stimuli but encompasses a large variety of auditory stimuli (including speech), this model is of general interest for neuroscientists. Therefore, professional musicians represent an ideal model in which to explore experience-driven changes (Schlaug et al., 1995a,b; Koelsch et al., 2002; Loui et al., 2011) with respect to the sensory-motor (Zatorre et al., 2007), cognitive (Jäncke, 2009; Moreno et al., 2011), and emotional (James et al., 2008) processing domains.

Compared with non-musicians, recent studies suggest that professional musicians have altered characteristics which may possibly influence emotional processing, such as better temporal discrimination (Agrillo and Piffer, 2012), enhanced auditory perception and related cortical organization (Francois and Schon, 2011; Marie et al., 2011; Elmer et al., 2012, 2013; Kühnis et al., 2013), and improved working memory (George and Coch, 2011).

However, superior musical expertise does not only encompass enhanced auditory and motor skills (Amir et al., 2003; Abdul-Kareem et al., 2011). It also involves altered emotional aspects of music perception. Although, principally, music is apt to modulate emotions in nearly everybody (Zatorre et al., 1994; Blood et al., 1999; Koelsch and Mulder, 2002; Baumgartner et al., 2006a,b; Sammler et al., 2007), it was hypothesized that the specific emotional reaction evoked by music is modulated by the degree of musical expertise (James et al., 2008).

Music is a continuous stream of transient auditory events that people perceive and respond to in an affective manner (Steinbeis et al., 2006). Music is dynamic and changes over time (Grewe et al., 2005); therefore, it is preferable to dynamically evaluate the change of emotions. To evaluate the quality of those fluctuating emotions, Russel's circumplex model (Russel, 1980) was used (Thayer and Faith, 2001; Hirokawa, 2004; Schubert, 2007). The valence axis describes the liking of the music and seems to be strongly dependent on consonant and dissonant tones (Dellacherie et al., 2011). The arousal axis was added

to make connections with psychoacoustic parameters such as sound intensity (Dean et al., 2011; Mikutta et al., 2013) and timbre (Frego, 1999). Additional factors include tempo (Nyklicek et al., 1997; Frego, 1999), rhythm (Bernardi et al., 2006; Mikutta et al., 2013), and expectation (Koelsch et al., 2002, 2007, 2008; Maidhof et al., 2009). In addition to the aforementioned parameters, it was hypothesized that the degree of arousal is dependent on listener-specific variables such as musical experience (Chapin et al., 2010) and knowledge of the actual piece (Scherer, 1995). Specifically, it was hypothesized that musical expertise changes music-induced emotions due to altered expectations (Pearce and Wiggins, 2006).

Because of the aforementioned altered neurophysiological representation, it is plausible that professional musicians have a different and/or more intense music-evoked experience of arousal. To investigate the experience-driven alteration of music-induced emotional arousal, it is, thus, important to employ measures that are sensitive to transient arousal-related neurophysiological changes. In this regard, the electroencephalogram (EEG) is particularly well suited because it has a high temporal resolution (Mikutta et al., 2012) and its sensitivity to arousal has been well-established (Sammler et al., 2007).

In the EEG, music-evoked alterations of arousal have been linked especially to the delta, theta, and alpha frequency bands (Sammler et al., 2007). Interestingly, the theta correlate was at a mid-frontal location. This frontal midline theta was correlated with glucose metabolism in the anterior cingulate cortex (ACC) at rest (Pizzagalli et al., 2003). The ACC has generally been implicated in emotional control (Critchley et al., 2003). A blood-oxygen-level-dependent (BOLD) activation of the ACC was observed due to pleasant emotions evoked by music (Blood and Zatorre, 2001), demonstrating its possibly important role in emotional processing.

Further, an asymmetrical frontal alpha distribution (Mikutta et al., 2012) and an asymmetrical parieto-temporal alpha distribution (Fu et al., 2001) were related to a heightened arousal level due to music. An arousal network, comprising frontal, temporal, parietal and occipital structures was stipulated by Baumgartner et al. (2006b). The sample of nine women showed low alpha activity in these regions during combined presentation of music and affective pictures. In an analysis across participants, a heightened level of arousal due to music was related to delta waves (Lin et al., 2010).

It was the aim of the present study to investigate the influence of musical experience on emotion-related EEG correlates. Therefore, the differences in the perceived (subjective arousal via ratings) and physiologically measured (EEG) arousal level between amateur and professional musicians were examined. We wanted to exclude novelty effects due to differences in the basic knowledge of the music stimulus. Thus, we chose the first movement of Beethoven's 5th symphony, a musical piece that has proved to be known by all of the amateur musicians (Mikutta et al., 2012). In addition, we had previously shown that this stimulus was apt to modulate arousal in amateur musicians (Mikutta et al., 2012). Based on previous EEG studies showing enhanced theta activity during pleasant music-induced emotional states in connection with arousal (Asada et al., 1999; Sammler et al., 2007), we expected to observe more intense central nervous system correlates of emotional activity, such as mid-frontal theta activation, in professional musicians. Since our previous study (Mikutta et al., 2012) showed frontal asymmetrical alpha oscillations in connection with changes in arousal in amateur musicians, we specifically expected to observe a more intense emotion-associated reaction, such as an alpha (frontal or parietal) asymmetry, in professional musicians (Mikutta et al., 2012). Therefore we use the amateur musicians (n = 17) from Mikutta et al., 2012 as control for comparison with the professional musicians for exploring differences in emotional reaction.

EXPERIMENTAL PROCEDURES

Participants

Fifteen professional musicians from the schools of fine arts in Berne, Basel, Feldkirch, and Vienna and 17 amateur musicians recruited from the in-house staff and the medical students took part in the present study. All 34 participants were right-handed. The mean age of the professional group was 25 years (range = 21–33). The professional group was comprised of seven males and eight females. The mean age of the amateur group was 24 (range = 17–33). The amateur group was comprised of 10 females and nine males. There was no significant between-groups difference in age or in gender. The amateur group was recruited at 2011 and the results were already used in the publication of Mikutta et al., 2012.

The inclusion criteria for the professional musicians were as follows: (1) the musician currently studied at a school of fine arts; or (2) the musician had completed their study of music and obtained a concert diploma. The inclusion criterion for the amateur musicians was that they were currently receiving instruction in a musical instrument. The exclusion criteria for both groups were the presence of central neurological disease, amblyacousia, psychiatric disorders, or the use of psychotropic medication. Amblyacousia was ruled out by testing the auditory threshold of 5–10 dB at 2000 Hz. Tests were performed using a Diatec screening audiometer (model AS-608). Of the professional musicians, 7, 3, 4, and 1 played the piano, percussion instruments, wind instruments, and a string instrument, respectively. All of them had a Bachelor or Master of Arts degree. None of the professional musicians had absolute pitch. On average, they practiced for 30 h per week (range = 25–40 h).

All of the amateur musicians played a musical instrument; 12, 5, 1, and 1 played the piano, string instruments, pan flute, and guitar, respectively.

Fourteen of the amateur musicians played for more than 5 years. They all received music lessons as amateur musicians in different styles (e.g., classical,