Gamma-band synchrony
Role of Music Perception in the Brain

Yuko Urakami*, Yoshikazu Washizawa, Koki Kawamura**, Kazuko Hiyoshi**, Andrzej Cichocki****

National Rehabilitation Center for Persons with Disabilities, Japan* urakami-yuko@rehab.go.jp
RIKEN Brain Science Institute Cichocki Laboratory for Advanced Brain Signal Processing, Japan**

Introduction

Music perception involves acoustic and auditory scene analysis, processing of interval relations, of musical syntax and semantics,and activation of premotor representations of actions. In the “dorsal pathway”, neurons in the parietal and frontal areas respond with similar characteristics (Bushara et al., 1999). Therefore, spatial information can be used for the programming of action. The “ventral pathway” includes the uncinate fasciculus that conveys visuo-auditory information to the prefrontal cortex (area 10) from the temporal lobe.

Previous studies have shown that listening to the music influences the cognitive activity of humans and the music-evoked emotions can modulate activity in virtually all limbic and paralimbic brain structures by means of functional neuroimaging techniques. The present study aimed to clarify the time-spatial neural networks during music perception of musicians and non-musicians using 60-ch electroencephalography (EEG).

Methods

Design & Procedure

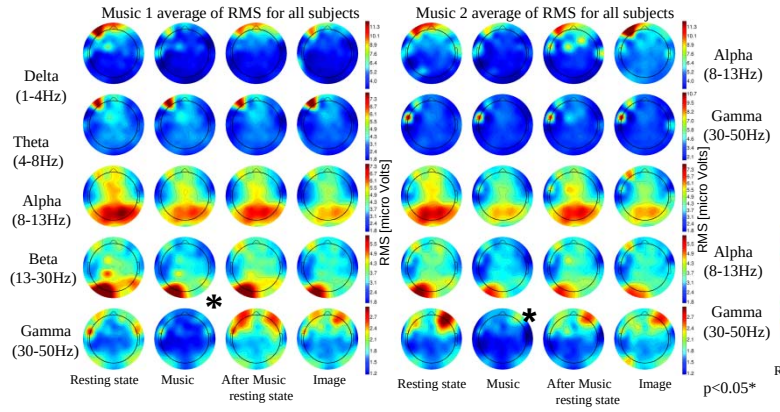
Music 1 : Anton Dvorak “From the New World Symphony”
The Symphony No. 9 in E Minor From the New World Largo D-flat major “Going home”

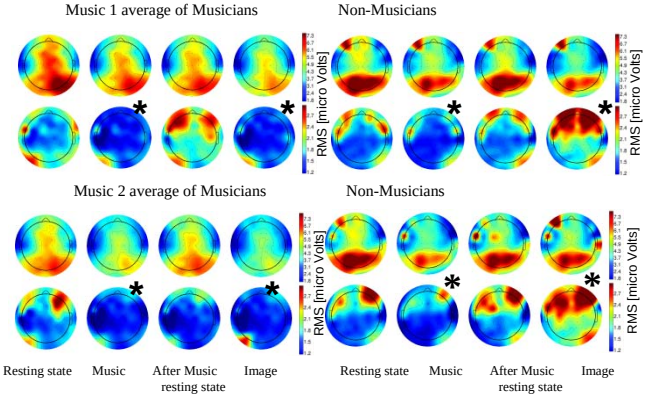
Music 2: Wolfgang Amadeus Mozart Requiem in D minor (K. 626) Sequence “Dies irae”.

11 subjects ;aged 21~25; 8 male, 2 female, 5 music-training students (musicians), 5 non music-training students (non-musicians) and one professional musician (singer) participated in this study.

Participants listened to the music from ear-phone with eyes-closed sitting in a dark experimental room. In three conditions; 1) resting state with eyes-closed (for 1 minute), 2) listening to the music (for 2.5 minutes of melody part) and 3) imaging the music without stimulation, examinations were performed by recording with a 60-ch EEG using Morlet Wavelet time-frequency analysis, and Root Mean Square (RMS) was calculated in each frequency-band. Average values of RMS were indicated in topograph maps. For statistical analysis one-side t-test and two-sides t-test were performed.

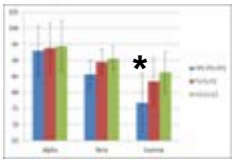
Results

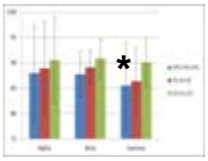




1. During listening to the music, compared with resting state, gamma activity was significantly decreased, especially in the prefrontal cortex Likewise, alpha activity was significantly decreased during listening to the music, also decreased during imaging the music as seen in left frontal, central and parietal lobes.

2. During music listening, the musicians’ gamma activity was significantly decreased in the temporal, parietal and occipital lobes compared with the non musicians’. During imaging the music, the musicians’ gamma activity was significantly decreased in temporal, parietal, and occipital lobes, whereas the non musicians’ gamma activity increased in the frontal lobe.

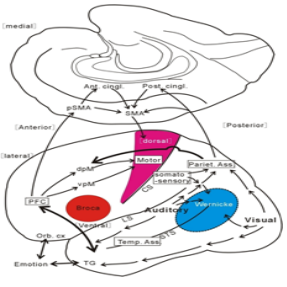




The rate of decrease of gamma activity in the frontal midline was greater in the anterior part (Fp1, Fp2, Fpz) compared with posterior part (F1,F2, Fz), and central part(C1,C2,Cz).

Discussion

In the auditory system, it is possible to consider the system as composed of such functional subdivisions as pure tones or harmony, high or low tones, forte or piano, as well as pitch and melody. The prefrontal cortex that contains Broca’s area and the posterior association area that contains Wernicke’s area are interconnected with a variety of long and short association fibers. The ventral part of the frontal lobe and the temporal pole are also interconnected, both of which have reciprocal connections with the amygdala. Thus, integration of recognition (logos) and emotion (pathos) occurs in the prefrontal cortex.



(Kawamura,2011)

1. A gamma-activity decreases during music perception especially in the anterior part of frontal lobe, it is strongly related to the integration of recognition and emotion which reflect the processing of music in a highly integrated level.
2. Musicians’ gamma activity significantly decreases during listening to the music in the temporal, parietal and occipital lobes compared with non musicians, which indicate the difference of auditory-processing mechanism as concerns tones or harmony, high or low tones, forte or piano, as well as pitch and melody.
3. The gamma synchronization shows that musicians image the music in the same or similar condition as they are listening to the music, that is, they do image and replay the music in the recollection of acoustic memory in the listening-to-the music state. In contrast, non-musicians’ gamma synchronization suggests the recollection of the integrated processing in the prefrontal cortex. The differences during music perception between musicians and non-musicians may reflect the difference of their musical training experiences and expert skills.

Acknowledgement

This research was supported by Grants-in-Aid for Scientific Research 23500473 (Japan Society for the Promotion of Science).

Gamma-band Synchrony; Role of Music Perception in the Brain

Yuko Urakami[1], Yoshikazu Washizawa[2)3)] ,Koki Kawamura[3) 4)] , Kazuko Hiyoshi[3) 5)] , Andrzej Cichocki[3)]

1) Hospital and Research Institute, National Rehabilitation Center for Persons with Disabilities, Tokorozawa, Japan.

2) Department of Communication Engineering and Informatics, The University of Electro-Communications, Tokyo, Japan.

3) RIKEN Brain Science Institute, Laboratory for Advanced Brain Signal Processing, Wako-shi, Japan.

4) Department of Anatomy, School of Medicine, Keio University, Tokyo, Japan.

5) Department of Functional Brain Imaging, Human Brain Research Center, Graduate School of Medicine, Kyoto University, Kyoto, Japan.

Objective: Music perception involves acoustic and auditory scene analysis, processing of interval relations, of musical syntax and semantics, and activation of premotor representations of actions. This study aimed to clarify the neural networks during music perception of musicians and non-musicians using 60-ch electroencephalography (EEG).Methods: We collected spontaneous brain activity in five musicians (four musical-trained students and one singer), five non-musical trained students while listening to “From the new world (Dvorak)” and “Requiem (Mozart)” for three minutes, being compared with resting state. Results: During listening to the music, compared with the resting state, gamma activity was significantly decreased, especially in the prefrontal cortex. Likewise, alpha activity was significantly decreased during listening to the music, also decreased during imaging the music as seen in the left frontal, central and parietal lobes. The rate of decrease of gamma activity in the frontal midline was greater in the anterior part (Fp1, Fp2, Fpz) compared with posterior part (F1,F2, Fz), and central part(C1,C2,Cz). During music listening, the musicians’ gamma activity was significantly decreased in the temporal, parietal and occipital lobes compared with the non musicians’. During imaging the music, the musicians’ gamma activity was significantly decreased in the temporal, parietal and occipital lobes, whereas the non musicians’ gamma activity increased in the frontal lobe. Discussion: A gamma-activity decreases during music perception especially in the anterior part of the frontal lobe; it is strongly related to the integration of recognition and emotion which reflect the processing of music in a highly integrated level. Musicians’ gamma activity significantly decreases during listening to the music in the temporal, parietal and occipital lobes compared with non musicians, which may indicate the difference of auditory-processing mechanism as concerns tones or harmony, high or low tones, forte or piano, as well as pitch and melody. The gamma synchronization shows that musicians can image the music in the same or similar condition as they are listening to the music, that is, they do image and replay the music in the recollection of acoustic memory in the listening-to-the music state. The differences in brain activities during music perception between musicians and non-musicians may reflect the different quality of their musical training experiences and expert skills.

Joint Annual Meeting ECNS（Electroencephalography and Clinical Neuroscience Society, International Society for Brain Electromagnetic Topography & International Society for Neuroimaging in Psychiatry).
Location: Bristol medical Center. Bristol, Tennessee USA. September 11-15.2012