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Response to Discussion on "Altered EEG Oscillatory brain Networks During Music-listening in Depression," *International Journal of Neural Systems*, 30:x (14 pages)

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1. Introduction

The authors appreciate the discusser's interest and critical comments on their paper. The discusser raised two main issues regarding the research presented in the paper. The first point was related to the practical application/usefulness of this research. The second point was related to the music therapy for a patient diagnosed with depression. It would say that the experience gained from the technical model of brain networks is limited for a fuller understanding of major depressive disorder (MDD). Therefore, an analysis with the interaction of environmental stimuli such as freely listening to music is required. A detailed response to the discusser's comments is provided as follows.

2. Biopsychosocial model in Depression

In the paper, the authors introduced an analytical framework for identifying temporal, spectral, and spatial changes in electrophysiological brain networks during music listening in major depression, which explored the effect of music stimuli on a patient with depression. It is concerning that the mental health professionals are still not clear about the origin and especially the etiological mechanism of MDD. As a consequence, there is not always unanimity about the best way to treat and prevent depression. It is one of the great challenges of psychiatry to advance understanding of the mechanisms which generate depression and to understand how they explain such a wide range of etiological and therapeutic factors (Garcia-Toro & Aguirre, 2007). Although studies about anatomical, functional and structural aberrations in brain functioning characteristic for Depression is abundant, it is limited for a more comprehensive understanding of MDD in only terms of the technical model of functional mental disorders. Thus, the biological information processing model such as bio-psycho-social model is required (Garcia-Toro & Aguirre, 2007; Schotte, Van Den Bossche, De Doncker, Claes, & Cosyns, 2006).

The two main viewpoints that were currently used to explain Depression are the biomedical perspective and the psychosocial perspective (Garcia-Toro & Aguirre, 2007). The biomedical perspective asserts that psychopathological syndromes are essentially caused by disturbances in the functioning of the brain, while from the psychosocial perspective life experiences are the main cause of the mental disorder. Usually, those double perspectives influence implicitly the different statements that are made about the mental disturbance (Spitzer,

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2001), although it is increasingly recognized that biological and psychosocial viewpoints are always involved, interacting in a complex way. It has also been noted that the biopsychosocial model has been incapable of inspiring empiric research into the etiology, diagnosis and treatment of Depression (Richter, 1999). Therefore, there is still an acute need for new conceptual bridges between the biomedical and psychosocial models.

Music provides bridges to investigate psychosocial – biological links. Over the past several decades, scholars have explored the biological role of music and its connection to brain disorders (Schäfer, Sedlmeier, Städtler, & Huron, 2013). Increasing evidence provided by clinical neuroscience concerning the effects of brain disorders promises to be particularly valuable in uncovering the underlying cognitive and neural architecture of music and for assessing candidate accounts of the biological role of music (Clark, Downey, & Warren, 2015). The stimulus used in the paper was the tango Adios Nonino by Astor Piazzolla. This piece of music has been selected and examined in the author's past articles since it has high range of variation in several musical features such as dynamics, timbre, tonality and rhythm, while having an appropriate duration for the experimental setting used (Alluri et al., 2012; Cong et al., 2013). Moreover, this music was expected to be used as standard stimulus to understand processing deficits in its psychosocial context.

3. Neural oscillatory basis of depression

The authors agree with the discusser that it might be better to use nonlinear analysis to discriminate between MDD patients and healthy controls during emotional processing. However, it is also meaningful and important to investigate the neural underpinning of depression using sub-bands of EEG while more and more evidence suggests that there are multiple functional connectivity issues in MDD, especially in the front-limbic system. Here, the authors would like to examine the neural oscillatory mechanism of depression by analyzing the sub-bands of EEG networks. Specifically, they would like to look at whether the frequency-specific networks of musical feature processing were disrupted in patients with MDD. Since many studies shown that MDD can be understood as a “network disease” with pathological changes in functional connectivity patterns (He et al., 2018) and the electrophysiological basis of these networks have been not elusive, it is interesting to look at the changes in electrical functional networks during natural music listening. Thus, the spatial ICA of Fourier envelopes has been applied here for data-driven characterization of oscillatory EEG activity. It has proven to be successful in characterizing the spatial, temporal, and spectral signatures of brain activities and gaining insights into electrophysiological underpinnings of resting-state networks using EEG (Li et al., 2018). The aim of this study is therefore to examine the neural oscillatory basis of such altered brain networks in depression especially during the music listening condition.

References

1. Alluri, V., Toiviainen, P., Jääskeläinen, I. P., Glerean, E., Sams, M., & Brattico, E. (2012). Large-scale brain networks emerge from dynamic processing of musical timbre, key and rhythm. Neuroimage, 59(4), 3677-3689.
2. Clark, C. N., Downey, L. E., & Warren, J. D. (2015). Brain disorders and the biological role of music. Social Cognitive and Affective Neuroscience, 10(3), 444-452.
3. Cong, F., Alluri, V., Nandi, A. K., Toiviainen, P., Fa, R., Abu-Jamous, B., . . . Huotilainen, M. (2013). Linking brain responses to naturalistic music through analysis of ongoing EEG and stimulus features. IEEE Transactions on Multimedia, 15(5), 1060-1069.
4. Garcia-Toro, M., & Aguirre, I. (2007). Biopsychosocial model in depression revisited. Medical hypotheses, 68(3), 683-691.
5. He, Y., Lim, S., Fortunato, S., Sporns, O., Zhang, L., Qiu, J., . . . Zuo, X.-N. (2018). Reconfiguration of cortical networks in MDD uncovered by multiscale community detection with fMRI. Cerebral Cortex, 28(4), 1383-1395.
6. Li, C., Yuan, H., Shou, G., Cha, Y.-H., Sunderam, S., Besio, W., & Ding, L. (2018). Cortical statistical correlation tomography of EEG resting state networks. Frontiers in neuroscience, 12, 365.
7. Richter, D. (1999). Chronic mental illness and the limits of the biopsychosocial model. Medicine, health care and philosophy, 2(1), 21-30.
8. Schäfer, T., Sedlmeier, P., Städtler, C., & Huron, D. (2013). The psychological functions of music listening. Frontiers in psychology, 4, 511.
9. Schotte, C. K., Van Den Bossche, B., De Doncker, D., Claes, S., & Cosyns, P. (2006). A biopsychosocial model as a guide for psychoeducation and treatment of depression. Depression and anxiety, 23(5), 312-324.
10. Spitzer, R. L. (2001). Values and assumptions in the development of DSM-III and DSM-III-R: An insider's perspective and a belated response to Sadler, Hulgus, and Agich's" On values in recent American psychiatric classification". The Journal of nervous and mental disease, 189(6), 351-359.