The Progression of Sensorimotor Regions and Default Mode Network Deactivation With Musical Background.

Grant Proposal

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The Progression of Sensorimotor Regions and Default Mode Network Deactivation With Musical Background.

There are many vital connections between music, musical talent, and the mind. Participation in musical activities works many areas and regions of the brain. Specifically, it has been shown that those involved in some form of music, whether through career or hobby, are more likely to retain sensorimotor regions of the brain and develop compensation to the regression of such areas as well as audiovisual capabilities. This can be seen in such works as “Successful aging of musicians: Preservation of sensorimotor regions aids audiovisual speech-in-noise perception” by Lei Zhang, Xiuyi Wang, Claude Alain, and Yi Du, and “Musical Training Shapes Structural Brain Development” by Krista L. Hyde, Jason Lerch, Andrea Norton, Marie Forgeard, Ellen Winner, Alan C. Evans and Gottfried Schlaug. These past studies have looked at how older musicians’ abilities to identify syllables through other noise, in comparison to the same abilities of older nonmusicians and younger nonmusicians using functional magnetic resonance imaging (fMRI) technology, and how consistent participation in musical activities can affect structural brain development respectively. These studies present valuable information as to the nature of the preservation of these brain areas, the growth present during musical training, and the deactivation of brain areas that control daily repetitive action, known as default mode networks (DMNs). It was found through the first mentioned study that older musicians had

a similar ability to identify syllables among moderate noise volume levels as younger nonmusicians while older nonmusicians struggled far more severely, as can be seen in figure 1. It was shown from the second mentioned study that Musical training and participation has large effects the development of the brain in specifically younger children, with those taking part in consistent lessons becoming significantly better at audiovisual, rhythm, and motor tests. This research has not studied particularly the effects of a set of participants with a varied experience with music, or how this experience affects the brain through the various ages. This study will attempt to expand on these results by looking at relationships between the level of musical training a participant has experienced in the past, these preservation benefits, and the strengthening or deterioration of these brain areas as a result of aging. This study will use an electroencephalogram (EEG) device rather than fMRI equipment, as it is more easily accessible, and allows for the recording of specific focus values from targeted brain regions. This will theoretically include the recording of less activity from DMNs, showing musical background's effect on these regions.

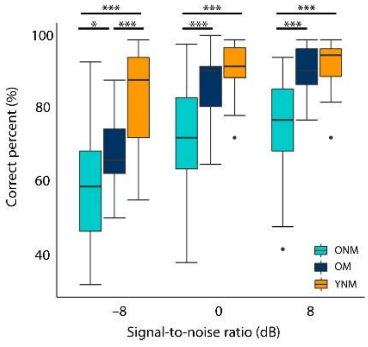

Figure 1: graph of correct percentage guessed syllables, and the syllable signal to noise ratio.

Section II: Specific Aims

The aim of this study includes finding a correlation between an increase in musical experience and training, and an increase in the ability to perceive sound through noise, or an increase in the prevention of hearing loss as an effect of age. This study will hopefully provide statistically significant results that speak to the potential and healthy benefits of incorporating musical training, and experience into the daily lives of most if not all people. A secondary aim of this study is to find a correlation between an increase in musical experience, and an increase in the deactivation of the default mode networks in the various brain regions. This correlation would give more insight into the general purpose, and use cases of these networks, as well as the effectiveness of musical training as a method of increasing the focus, and perception effectiveness of a person.

Section III: Project Goals and Methodology

Relevance/Significance

The loss of sensory cognitive abilities, and specifically the loss of hearing, are issues that many people face with age. This study attempts to discover a connection between higher experience with music as part of everyday life, and a increase in these abilities, or the prevention of the loss of hearing with age. If this connection can be established, those suffering from hearing loss, other sensorimotor afflictions, and all people hoping to prevent these potential issues can be given a simple and enjoyable aid in the form of consistent musical training.

Innovation

This study is an addition to work done in the 2023 study *Successful aging of musicians: Preservation of sensorimotor regions aids audiovisual speech-in-noise perception* by Lei Zhang et al. This past study used audiovisual tests similar to the ones to be used in this current study to determine how older musicians in comparison to older non-musicians, as well as younger non-musicians in terms of ability to hear syllables through noise. The current study would expand on this past study with the introduction of musicians and non-musicians of all ages and skill levels to determine when and how this hearing ability improvement, or preservation occurs. This study also introduces the use of

electroencephalographic equipment as a way to research the deactivation of default mode networks, as past studies have either not included default mode networks as part of their research or have used fMRI and other recording methods to obtain information and data about these regions. The use of EEG equipment will allow the direct recording of the activity coming from these regions as a way to tell the effectiveness of the deactivation, and therefore lower brain wave output, during the participant testing.

Methodology

The testing done over the course of this study will include the participation of willing volunteers in a series of audiovisual tests, in which they will be played an audio clip including a syllable, with the addition of background noise. The level of background noise in comparison to the syllables will be varied from louder to quieter, and the participants will be asked to identify the syllable they are hearing through the noise. The number of tests performed, and the number of correct syllables guessed, will be recorded. A statistical analysis will be performed on the mean of correct answers of the groups comparing those participants with musical background, and those without, in each of the age groups, to observe how likely it is that our result matches the hypothesis of those with musical experience having greater ability to determine the syllable in question through higher levels of background noise. While these tests are being performed, participants will

wear an electroencephalography headset to record the brainwaves originating from specified areas of the brain with the default mode networks in question. Statistical analysis will also be performed on these results in similar fashion to the audiovisual tests, in which separated by age, the brainwaves of the musicians and the brainwaves of the non-musicians will be compared for differences in the deactivation of those specified regions.

Section IV: Resources/Equipment

One of the main resources needed for this study is participants willing to take part in audiovisual tests, and brainwave imaging. These participants will hopefully be of different ages, ranging from adolescent, to middle-aged, to elderly. This is necessary to test how these audiovisual reactions affect different ages, and to attempt to determine when hearing loss prevention, or improvement starts. These participants will also be of different musical experiences, with some listening to music, while others having played instruments or sang as a part of their daily lives. This is to test the effects of differing musical backgrounds as they relate to hearing improvement, and deactivation of default mode networks. Another main component of this study is the electroencephalography equipment necessary to read the brainwaves of the targeted brain regions during testing. This will be used for all participant tests to study deactivation of default mode networks in specific areas of the brain. Foam pellets used in each EEG node will also be required to get accurate readings from those brain regions, and cannot be reused between tests, so a constant supply will be necessary. The last main piece of equipment needed will be audio equipment used for presenting the audio tests, including the general noise and the syllables participants are asked to identify. Headphones, and a device capable of running recordings, most likely a computer, will be used for this purpose.

Section V: Ethical Considerations

The main ethical considerations are the use of human participants for data from this study. Participants will be asked to wear and be monitored by a headset reading the electromagnetic waves coming from regions in their brain. Any ethical concerns surrounding the use of the headset are unfounded, as these headsets are noninvasive, pose no electrical output or threat, and have been FDA approved in both wet electrode and dry electrode formats (Ciccone, 2024). There are few ethical concerns surrounding participant privacy as no personal details about participants or their individual scores on any audiovisual or electroencephalographic tests will be recorded in any manner connecting to the participant. Audiovisual tests pose no ethical concerns as volume will not exceed any harmful value, and personal participant preferences on listening format will be taken into account for all tests. Foam pellets used for clear connection to the scalp will be completely replaced between tests and participants to ensure physical and hygiene-based issues, and cross contamination are eliminated as concerns. There are no other identifiable ethical considerations at this time.

Section VI: Preliminary Data

Without the ability and permission to acquire data from participants, preliminary data for this study came from performing EEG data readings on main researcher. The EEG headset collected information on the activity of the default mode network areas in the main researcher's brain during resting brain activity (figure 2), as well as while they were playing their instrument (figure 3). Since reading and playing music is a focus consuming task and requires attention it can be seen through the differences in the two graphs that the default mode networks showed significantly reduced alpha activity during the instrument trial. Alpha waves typically mean that those brain regions are under high use by the brain. Therefore, the absence of the alpha spike in the second trial shows that the default mode networks were under significantly less use while the participant was playing their instrument. This agrees with this study's hypothesis that increased musical experience leads to less use of these brain regions.

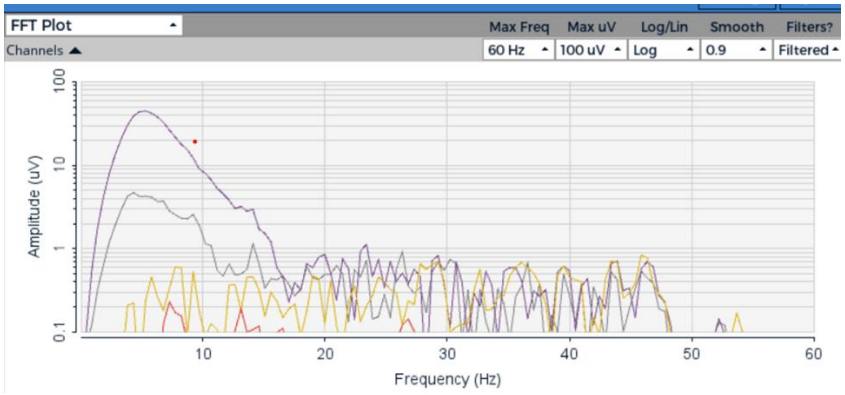

Figure 2: EEG frequency and amplitude graph during resting state testing of main researcher.

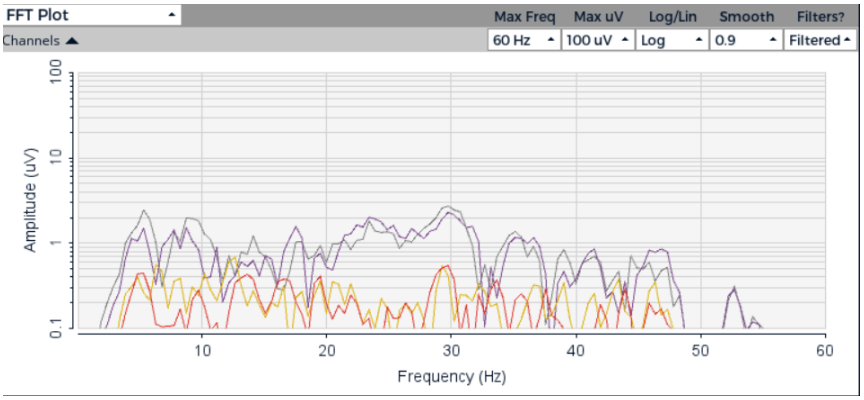

Figure 3: EEG frequency and amplitude graph during instrument trial of main researcher.

Section VII: References

Brandes, V. M. (2013). *Systems and Methods for Music Therapy* (US20140249358A1). U.S. Patent and Trademark Office. https://patents.google.com/patent/US20140249358A1/en

Ciccone, I. (2024). FDA Clears Zeto's Adjustable ONE Headset for EEG Brain Monitoring. *NeurologyLive.* *https://www.neurologylive.com/view/fda-clears-zeto-adjustable-one-headset-eeg-brain-monitoring*

Crone, J.S., Ladurner, G., Höller, Y., Golaszewski, S., Trinka, E., & Kronbichler, M. (2011). Deactivation of the Default Mode Network as a Marker of Impaired Consciousness: An fMRI Study. PLoS ONE 6(10), e26373. https://doi.org/10.1371/journal.pone.0026373

Deshmukh, V.D. (2023). The Electroencephalographic Brainwave Spectrum, Mindful Meditation, and Awareness. *International Journal of Yoga* 16(1),42-48. DOI: 10.4103/ijoy.ijoy_34_23

Gevins, A., Howard, R., & Sandoval, A. (2005). *EEG electrode headset* (US7551952B2). U.S. Patent and Trademark Office. https://patents.google.com/patent/US7551952B2/en

Hlinka, J., Alexakis , C., Diukova, A., Liddle, P.F., & Auer, D.P. (2010). Slow EEG

pattern predicts reduced intrinsic functional connectivity in the default mode network: An inter-subject analysis. NeuroImage 53(1), 239-246. https://doi.org/10.1016/j.neuroimage.2010.06.002

Hyde, K. L., Lerch, J., Norton, A., Forgeard, M., Winner, E., Evans A. C., & Schlaug, G. (2009). Musical Training Shapes Structural Brain Development. Journal Of Neuroscience, 29(10), 3019-3025. https://doi.org/10.1523/JNEUROSCI.5118-08.2009

Moskowitz C. (2009, March 6) *Musicians Read Emotions Better.* Live Science. https://www.livescience.com/9626-musicians-read-emotions.html

Neuner, I., Arrubla, J., Werner, C.J., Hitz, K., Boers, F., Kawohl, W., & Shah, J. (2014). The Default Mode Network and EEG Regional Spectral Power: A Simultaneous fMRI-EEG Study. *PLoS ONE* 9(2), e88214. https://doi.org/10.1371/journal.pone.0088214

Zhang, L., Wang, X., Alain, C., & Du, Y. (2023). Successful aging of musicians: Preservation of sensorimotor regions aids audiovisual speech-in-noise perception. Science Advances, 9(17). DOI: 10.1126/sciadv.adg7056