Short-term Musical Training and its Positive Effects on Neural Pitch Encoding in Children with Autism Spectrum Disorder

Working in the Kraus Auditory Neuroscience Laboratory for the past two years has opened my eyes to the numerous benefits auditory and musical training can have on the brain. Additionally, having worked more than eight years with people who have Autism Spectrum Disorder (ASD), which impairs the capacity for interaction and communication, I began to wonder if training could prove to be beneficial to this population. The tone of one's voice is determined by pitch; however, if an individual with ASD had deficits in neural encoding, he or she may be unable to interpret the "tone of voice" and grasp the connotation behind what is being said when communicating with others. Some individuals with ASD have been found to have a deficiency in neural encoding and following of pitch (Russo et al., 2008). Piecing together previous research and experience, I began to wonder if short-term musical training could positively affect the neural response of a child with ASD. Therefore, I will be testing to see if short-term musical instrument instruction can improve neural speech encoding and following of pitch in children with ASD. Demonstration of the effectiveness of a short-term private musical training program for improving neural encoding and pitch following would suggest that short-term musical training can be an important adjunct to the management of deficits in detecting "tone of voice" in children with autism spectrum disorder.

Research studies have shown that auditory training can improve neural encoding in participants (Song et al., 2008, Warrier et al. 2004). Research studies have shown that the use of software based auditory training (Fast ForWord) brought about significant improvements in expressive and receptive language measures in children with ASD (Agocs MM et al., 2006). In a recent research project, relative to six control children with ASD who did not complete Fast ForWord, training-related changes were found in brainstem response timing (three children) and pitch-tracking (one child), and cortical response timing (all five children) after Fast ForWord use (Russo, Hornickel et al., 2010).

Musical training has also proven to have multiple benefits, including improved neural processing and following of pitch (Parberry-Clark et al., 2009, Wong et al., 2007). Because individuals with ASD have deficits in brainstem encoding of pitch (Russo et al., 2008), musical training may provide an effective tool for management of these deficits. Numerous case studies have shown that music therapy improves both production and interpretation of others' intonation (Miller and Toca, 1979; Hoelzley, 1993). Music therapy has played an effective role in facilitating pitch learning in language (Schon et al., 2004). Additionally, long-term musical experience improves neural timing in younger (Parbery-Clark et al., 2009) and older adults (Parbery-Clark et al., 2010). Although research has shown that musical experience benefits brainstem encoding in young adults who do not have disabilities, this effect has not been demonstrated in individuals with ASD. Kellerman and colleagues (2005) suggest that the repetitive nature of music is attractive to individuals with ASD and it has also been proposed that the technical aspects of music appeal to individuals with ASD (Levitin, 2006). These studies lead me to believe this approach could be helpful for individuals with ASD.

This particular study will (a) examine the cortical responses of children with autism to the stimulus syllable ('da') (b) compare brainstem pitch tracking recorded before and after short-term musical training to a syllable containing a vowel with changing pitch ('ya'), and (c) observe any changes made in the accuracy of the frequency discrimination task. The speech evoked brainstem and cortical responses to syllables such as 'ya' and 'da' allow for the extraction of characteristics about encoding speech such as onset, offset, and periodicity (Russo et al., 2009).

I am the founder and current president of Academy of Music and Arts for Special Education (AMASE), which is a student organization at Northwestern that teaches young students with autism how to play musical instruments. The incoming new students will be informed of the opportunity to participate in this research study in addition to the ensemble. Other participants, including participants who will not receive musical training, will be recruited from District 65 and Have Dreams, an afterschool program for children with autism. Music lessons will be provided by five Northwestern University undergraduates recruited from Bienen School of Music. Participants in the music training group will be taking two 30-minute lessons a week and will also be practicing at least 30 minutes a day for four days a week. Parents will keep a record of the practice sessions daily. The participants will be getting as much exposure to music as possible. During spring quarter 2012, I conducted a preliminary study with three participants engaging in musical training and practice for six weeks; therefore the elements are in place for carrying out the logistics of the experiment, and my experience shows that I can expect that the students will successfully meet the practicing requirements.

Five children with autism (ages 7-12) will participate in musical training and five children will participate in the control group and will have no musical training. These children will have been professionally diagnosed with autism and have had no prior musical experience. Data from the ten participants will be collected three times: preliminary data, post-8 weeks without musical training, and post-8 weeks with or without musical training in order to control for change due to chance. The participant's brainstem responses will be recorded by placing electrodes on the participant's forehead, scalp, and right earlobe. The participants will be watching a movie comfortably in a chair while the speech syllable "ya" (with a changing pitch) is simultaneously presented to the right ear. The cortical responses of the participants to the speech syllable "da" in quiet will also be recorded in the same manner. The participants will also complete the frequency discrimination task in the IHR multi-centre study of Auditory Processing (IMAP) computer program to assess the participants' abilities to accurately discriminate between different pitches. In the frequency discrimination task, the participants will listen to three sounds, two of which are of the same frequency and one that is different in frequency from the other two sounds. The participant will be asked to discriminate between the three sounds and will press a button to distinguish the sounds that were different in frequency. While the participant is completing the IMAP task, the parent or guardian of the participant will fill out the *Gilliam Autism Rating Scale* questionnaire. The Gilliam Autism Rating Scale will be used to evaluate the social interaction skills of the participant in everyday life.

Given the variable nature of ASD, a single-subject case study design will be conducted for all ten participants. Responses from the musical training group will be compared to the amount of change due to chance by comparing each individual's data with the average amount of change from the control group. A significant change would be 1 standard deviation from the mean control change; this criterion is often used for clinical diagnosis (Russo et al., 2010). I will analyze the data that was collected over a period of sixteen weeks. I will analyze pre- and both post-non music training and post-music training brainstem pitch-tracking responses to the falling speech syllable "ya" obtained from each participant. Cortical responses to "da" in quiet will also be analyzed to note for any changes in response timing to the stimulus. Lastly, I will also look for improvement in the frequency discrimination task.

I have been working in Nina Kraus' Auditory Neuroscience Lab at Northwestern University since Fall 2010. During my time at the lab, I have learned how to record auditory brainstem responses through the system Neuroscan and have run data through pre-made programs in Matlab. Using SPSS software, I have also developed histograms of frequencies of the peaks to determine the averages of participants' data. I have taken various CSD classes including Biological Foundations of Speech and Music (CSD 310). From these classes, I have gained insight into the structure of the brain and the brainstem, have acquired an understanding of brain plasticity training programs such as FastFoward, and have learned more about the anatomy and physiology of the central auditory pathway and about experience-related neural plasticity. The Northwestern Institutional Review Board has approved this project.

I will use this research opportunity as part of my senior honors thesis. I am very interested in studying the effects of music on children with autism. Working in the Kraus lab these past few years, including research through the Summer Undergraduate Research Grant (2011) has helped me immensely with the experience and knowledge of collecting and analyzing data for specific populations of people and to see how training can affect brainstem responses. In the future, I would like to go to medical school and explore the possibilities of helping children with neural and behavioral disabilities.

Works Cited

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