Comparison of Spatial Reasoning Skills Among String and Non-String Musicians

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INTRODUCTION

Music is universal across human cultures and has been a part of many societies for centuries. The earliest record of a musical instrument is a 35,000 year old bone flute that was found in Germany (Wilford, 2009). Since homosapiens have been engaged in musical instrument practice for thousands of years it can reasonably be asserted that music can play a role in the development of the human brain. Infants are capable of demonstrating musical intelligence, such as, showing preferences for consonant combinations of tones (Zatorre, 2005). Musical instrument involvement, such as, creating music includes an exciting compilation of nearly every human cognitive function; it is a complicated process of coordinating eyes, ears, and hands in time. There is an increasing amount of evidence supporting that the study of the brain and music can be mutually revealing, and provide key information about how the brain functions (Zatorre, 2005).

There are a number of structural brain differences identified when comparing musicians to their nonmusical counterparts. For instance, increased cortical representation of the left hand in string instrument players who started instruction before the age of twelve (Elbert, Pantev, Wienbruch, Rockstroh, & Taub, 1995). Also, piano players, who began instruction at the age of six, were found to have larger corpus callosi when compared to non-musicians (Schlaug, Jancke, Huang, & Steinmetz, 1995). In addition, increased gray matter volume in the anteromedial Heschl's gyrus related to pitch perception (Schneider et al., 2005) and in the Broca's area related to years of playing as an orchestra instrumentalist (Sluming et al., 2002). This is possibly due to the long-term regular and intensive training practices of musicians (Habibi et al., 2018). There is

a growing body of evidence that supports musical instrument practice has a positive impact on growth throughout the brain.

A key part of one's general capacity to make sense of the world is to accurately predict patterns that will be unveiled (Zatorre, 2005). Practicing a musical instrument involves pattern recognition, development, and anticipation. There are many exercises within typical musical instruction that may help in aiding improvements of internal processing systems, such as, language analytic and spatial reasoning. Clearly music involves a deep understanding of patterns, as does spatial reasoning. There may be an interaction between brain development, acquisition, and maintenance of musical visuospatial skills (Sluming et al., 2002), which promotes generation or retention of functionally relevant cortical tissue. This can be utilized to promote complex nonmusical tasks, such as, solving spatial reasoning problems.

Spatial reasoning is involved when we think ahead several moves, developing and evaluating patterns in space and time. It is the ability to manufacture, maintain, manipulate, and identify complex mental images without external sensory input or feedback (Shaw & Bodner, 1999). Spatial reasoning is an important skill that is essential for success in science, technology, engineering, and mathematics (STEM) achievement (Stieff & Uttal, 2015). A 50-year longitudinal study found that participants with relatively strong spatial abilities tended to gravitate towards, and excel in STEM fields (Wai, Lubinski, & Benbow, 2009). If spatial reasoning skills can be developed and enhanced through musical practice, it would be beneficial for those who want to excel in STEM fields to practice an instrument.

String instruments (chordophones) are functionally different than woodwind and brass instruments (aerophones) in the way that they produce sound (Hornbostel and Sachs, 1914), and

therefore they require different skills to gain proficiency. When playing a string instrument a sophisticated understanding of fingerboard geography is essential. Additionally, both hands are simultaneously completing different functions. In simplistic terms, one hand is responsible for selecting pitches while the other is creating rhythm, dynamics, and timbre. Each hand is being manipulated in space to utilize different patterns. In comparison, aerophones only employ the hands to aid in pitch selection while the rhythm, dynamics, and timbre are manipulated by the instrumentalists' use of their lungs. The increased, and arguably more complex, involvement of the hands while playing a chordophone may provide extra musical benefits that exceed those gained by playing an aerophone.

The Trion Model of the cortex provides neurophysiological insights that propose particular neural firing patterns, arranged in a complex spatial-temporal code across large regions of the cortex, are used during both musical and spatial reasoning tasks (Leng and Shaw, 1991). This model is based on Mountcastle's (1950) Columnar Organization Principle, which is a widely adopted theory that explains the cortical processing of information. The Trion Model serves as a mathematical representation of a neuroscientific framework, which demonstrates the relationship between music and spatial cognition. According to this model the structured cortex, which is present at birth, has an inherent collection of spatial temporal firing patterns which can be excited and strengthened by changes in connectivity via a Hebb learning rule (Hebb, 1949). Over time, these firing patterns evolve to form the common neural language of the cortex.

A number of researchers have displayed that students involved with musical instrument training have improved scores on measures of spatial temporal abilities when compared to students with no musical training (e.g., Hurwitz, Wolff, Bortnick, & Kokas, 1975; Rauscher

1993; Rauscher et al., 1997; Gromko & Poorman, 1998; Rauscher, 1999; Costa-Giomi, 1999; Rauscher & Zupan, 2000; Bilhartz, Bruhn, & Olson, 2000; Hanson, 2003; Zafranas, 2004; Sluming et al., 2007; Spelke, 2008; Sanders, 2012). These studies leave a number of interesting questions unexplored. For example, there is a lack of studies that analyze the spatial reasoning skills of instrumentalists that perform on a professional level. Also lacking is a comparison of the effectiveness of different instruments to enhance an individual's spatial reasoning abilities. This studies aims to provide insight on the potential differences in spatial reasoning abilities of chordophone and aerophone instrument players. It was predicted that the chordophone instrumentalists would have significantly improved spatial reasoning scores when compared to the aerophone instrumentalists.

There are several reasons this information is worth gathering. The results from this study and ones like it can help to influence pedagogical decisions and could help policy makers prioritize where to make investments (Rauscher and Zupan, 2000). This research provides a strong developmental argument for K-12 schools to invest in band and orchestra programs. Also, educators and parents who are interested in developing STEM skills along with musical skills can encourage children to string instruments. As well as, development and maintenance of musical performance abilities throughout one's life can extend to benefit in nonmusical cognitive domains (Sluming et al., 2007).

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