The power of music on the brain

A study on the way music can anatomically alter the brain found that, amongst identical twins, the twin who had at least 1,000 hours of training on the keyboard had more advanced gray matter and white matter when compared to the twin who had no musical training.

Ban Alamin

This study sought to determine the effects of training on neuroanatomy and discovered that extensive musical training can induce brain changes, including greater cortical thickness, more developed white matter microstructure, and an increase in gray matter volume. The results of this study are important to further understand how the causal effects of practicing a skill can impact the brain's ability to adapt and form new connections.

The relationship between expertise in a skill and regional brain anatomy is a topic of extensive investigation. However, the specific causal effects of training on the brain without the influence of genetic factors remains unclear. In this article published by *OxfordAcademic*, which describes a study conducted by Örjan de Manzano and Fredrick Ullén, sought to determine the differences in brain anatomy between musical experts and non-experts.[1] This study was completed by observing the structural differences in the brains of nine pairs of monozygotic twins where one sibling in each pair played a keyboard instrument, and the other did not. This experiment found that even when controlling for genetic and early environmental factors there were still significant observable differences in both gray matter and white matter microstructure between the twins. These findings are important because the ways in which the brain's structural plasticity is affected can be used to better understand why the brain changes as a result of different practices and can be utilized in further research regarding learning and brain development.

From previous research, it is known that playing an instrument changes how the brain interprets a wide range of sensory information. Due to this, musicians have been ideal subjects for the role of long-term plasticity in the brain.[2] The plasticity of the brain refers to the brain's ability to change its physical structure and form new connections in response to learning or brain injury.[3] This influences the functionality of the brain and can create new patterns of organization within the brain.[2] For example, it was found in a previous study that London taxi drivers' hippocampal gray matter volume correlated with the level of driving experience.[4] Similarly, another past study found that just 15 months of musical training in early childhood lead to structural brain changes that were different from typical brain development.[5] These studies have solidified the fact that there is a relationship between training and differences in brain structure both during development and throughout adulthood. In comparison, this study seeks to clarify whether there is a direct relationship and how genetic factors come into play.

In this study a set of 9 pairs of monozygotic twins between ages of 31 to 47 were analyzed. One sibling in each pair had been playing a keyboard instrument with at least 1000 hours of experience, while the other did not. The musical history of each sibling was determined through a survey. Structural and functional MRI (magnetic resonance imaging) data of each sibling was acquired, and cortical thickness was analyzed with a FreeSurfer brain MRI program.[6] In order to

localize regions of interest, each musical sibling played simple melodies, and the corresponding clusters of activity in specific regions were observed. Diffusion weighted images, fiber tractography, and VBM (Voxel-Based Morphometry) analysis were also completed. All data was analyzed through a linear mixed model, and within-pair differences were analyzed with paired t-tests.[1]

Overall, the data indicated a correlation between musical training experience and differences in brain structure. It was found that the musical twins had greater gray matter volume in their left cerebellar lobules, greater cortical thickness in their left cerebral auditory motor network, and more developed white matter microstructure in their bilateral hemispheres.[1] Additionally, these areas were found to be related to the auditory network of the brain.[7] Regarding cortical thickness, the within-pair differences would have been higher, but a discordance occurred due to one pair of twins who both had early childhood musical training. Later one sibling stopped playing while the other continued. Overall, the findings clearly support the claim that extensive musical training increases the development of the auditory-motor network.

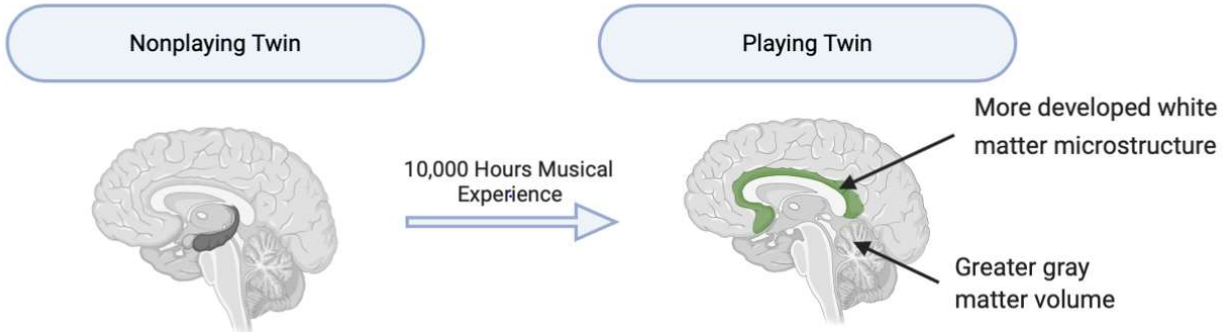

Figure 1. Anatomical differences between monozygotic twins were apparent with one twin having at least 1,000 hours of musical experience. This included more developed white matter in the corpus callosum and increases in gray matter along with cerebellar lobule of the auditory cortex. The anatomical differences were found to be influenced by causal effects of practice rather than genetic factors.

This study is significant because it shows how the brain can change and develop differently based only on the amount of musical training done and not including genetic predispositions. This is also significant regarding children with developmental disorders and adults with neurological diseases where the ability of the brain to undergo structural changes in response to the environment is hindered.[8] From this study, further research can be done to evaluate the learning process in people with disorders. However, this study could have been done with a larger sample in order to determine more accurate effects of training on a larger scale. Additionally, some of the discordances that occurred within the experiment could have been influenced by general developmental factors. It has been seen in previous research that differences occur in structural brain plasticity and behavior from early stages in development.[9] These factors are always present and indicate the unpredictable outcome of development that may have contributed to differences in brain structures between siblings, even those who are genetically identical. In conclusion, the study may have been influenced by early developmental factors, but the results indicate that there is an undeniable causal effect of expert musical training on the structural plasticity of the brain.

References

1. de Manzano, Ö., & Ullén, F. (2018). Same genes, different brains: neuroanatomical differences between monozygotic twins discordant for musical training. *Cerebral Cortex*, *28*(1), 387-394.
2. Koeneke, S., Lutz, K., Wüstenberg, T., & Jäncke, L. (2004). Long-term training affects cerebellar processing in skilled keyboard players. *Neuroreport*, *15*(8), 1279-1282. National Research Council. 2000. *How People Learn: Brain, Mind, Experience, and School: Expanded Edition*. Washington, DC: The National Academies Press. https://doi.org/10.17226/9853
3. Voss, P., Thomas, M. E., Cisneros-Franco, J. M., & de Villers-Sidani, É. (2017). Dynamic Brains and the Changing Rules of Neuroplasticity: Implications for Learning and Recovery. *Frontiers in psychology*, *8*, 1657. https://doi.org/10.3389/fpsyg.2017.01657
4. Jolles, D. D., & Crone, E. A. (2012). Training the developing brain: a neurocognitive perspective. *Frontiers in human neuroscience*, *6*, 76. https://doi.org/10.3389/fnhum.2012.00076
5. Hyde, K. L., Lerch, J., Norton, A., Forgeard, M., Winner, E., Evans, A. C., & Schlaug, G. (2009). Musical training shapes structural brain development. *The Journal of neuroscience: the official journal of the Society for Neuroscience*, *29*(10), 3019–3025. https://doi.org/10.1523/JNEUROSCI.5118-08.2009
6. Fischl B, Dale AM. 2000. Measuring the thickness of the human cerebral cortex from magnetic resonance images. Proc Natl Acad Sci USA. 97:11050–11055.
7. Barrett, K. C., Ashley, R., Strait, D. L., & Kraus, N. (2013). Art and science: how musical training shapes the brain. *Frontiers in psychology*, *4*, 713. https://doi.org/10.3389/fpsyg.2013.00713
8. Cramer, S. C., Sur, M., Dobkin, B. H., O'Brien, C., Sanger, T. D., Trojanowski, J. Q., Rumsey, J. M., Hicks, R., Cameron, J., Chen, D., Chen, W. G., Cohen, L. G., deCharms, C., Duffy, C. J., Eden, G. F., Fetz, E. E., Filart, R., Freund, M., Grant, S. J., Haber, S., … Vinogradov, S. (2011). Harnessing neuroplasticity for clinical applications. *Brain : a journal of neurology*, *134*(Pt 6), 1591–1609. https://doi.org/10.1093/brain/awr039
9. Lindenberger U, Kempermann G. 2013. Emergence of individuality in genetically identical mice. Science. 340:756–759.