BCI Lab Report for the Effect of Playing the Violin and Clarinet on Brain Activity

Your Research Background info:

Past research has established that playing music is a beneficial activity for brain development and may be better at fostering intellectual development and audiovisual technique than other extracurriculars like theater. Children who maintain musical education throughout their lives often receive profound mental benefits, ranging from social to emotional skills. The benefits of playing a musical instrument are hard to measure, but researchers have tried using different techniques like IQ tests or memory tests. In our research experiment, we use a brain computer interface (BCI) to capture brain waves as musicians play in various styles on the violin and clarinet to discover trends between styles and instrument types.

Your Experiment Procedure

1. Download the API for the OpenBCI GUI and Java. Connect the dongle to the computer. Set up the device.
2. Wipe your forehead with alcohol wipes. Attach the headpiece securely with all points of contact. Make sure that the headband setup is symmetrical with the monitors connected in the correct positions.
3. Turn the headpiece on and connect the computer to your headpiece. Run a trial for control with the musician doing nothing. Then run more trials for each: a major scale, a slow piece, a fast piece, and a piece to help get in the zone. The musician closes their eyes when in the zone to indicate to those recording data.
4. Clean up. Put the dongle back in the packet for future experimental use. Make sure that the wires in the headset are not tangled together so that the equipment is not damaged.
5. Repeat steps 2-4 on the second day with a second musician.

Quad Charts & Data Analysis:

Please insert 5 quad charts for your biosensing data and your analysis
VIOLIN-MICHAEL
Control:

In the zone:

Not in the zone:

Fast:

Slow:

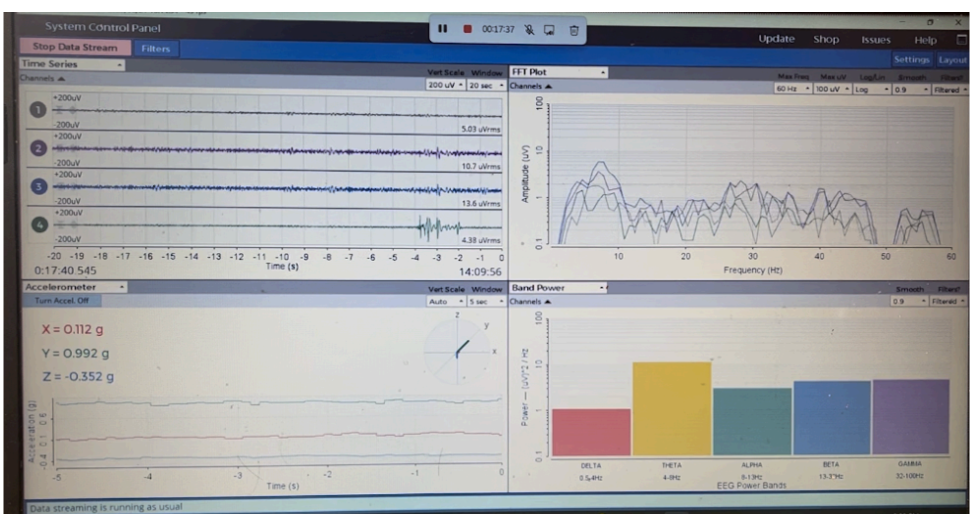
CLARINET-KARTHIK

Control:

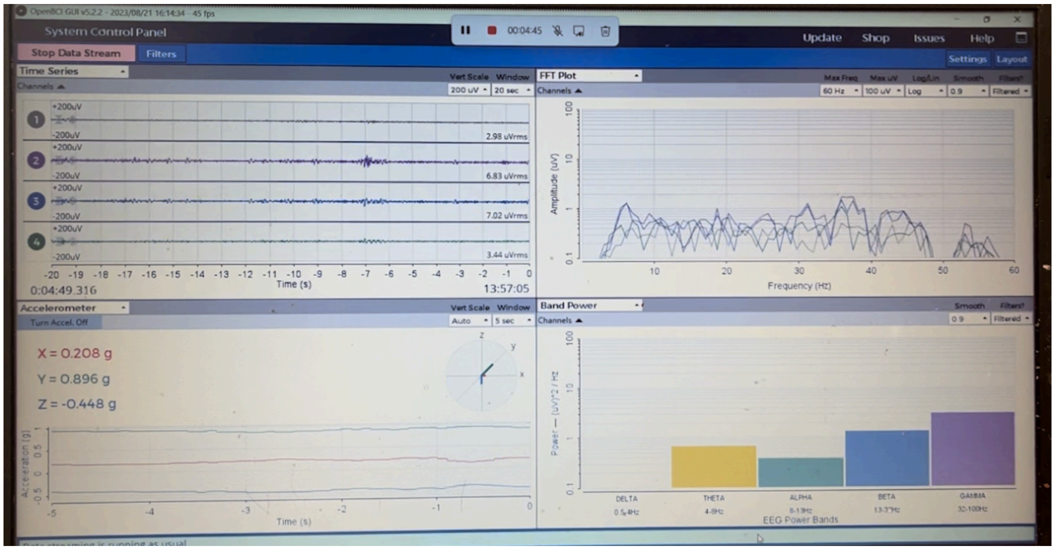
In zone:

Not in zone:

Fast:



Slow:



Analysis:

- In general, the clarinet data showed a lower degree of fluctuation within the data set. This probably results from the playing style of a string instrument compared to that of a wind instrument producing disturbances that lead to increases in impedance. We used the same equipment for both days, so there should be no discrepancies based on the piece of equipment.
- We saw a sharp rise in impedance and brain wave levels when the musician being tested closed their eyes. This is probably related to patterns relating to focusing or the type of thinking inside the body when the musician is playing. These same signals were used to produce accompaniment in a reference that we consulted while researching for this experiment.
- During the control set, we noticed brain waves predominantly in the theta range, showing a relaxed state of playing while the musicians held their instruments but did not play them. A similar ratio can be seen during both musicians' performances of fast pieces. This can show a more relaxed state for musicians when they play those pieces.
- We saw a similar pattern with higher-frequency waves when Michael played some portions of the fast piece and his slow piece, although there were slightly more theta waves in those cases.
- We saw peaks in alpha waves during musical performances that had a more artistic and free-moving appeal to them, which makes sense because these waves are associated with relaxation and artistic expression. We also saw peaks in these brain waves when the performer closed their eyes. This happened when they were "in the zone," and ratios of gamma and beta waves were very consistent.
- We generally saw higher peaks in activity during faster pieces rather than during familiar progressions like "Happy Birthday" and scales. This is probably due to the level of focus involved in musicians when they play each of those pieces.
- When the musicians were playing a slow piece, both showed a ratio of the other waves compared to the delta wave frequency being high, where the delta wave is lower. Specifically for clarinet, the ratio of delta wave to the other wave frequencies is extremely low for the slow pieces as well as when the clarinetist was not in the zone for the slow piece (much lower and much more drastic compared to the violin).

Conclusion

R (claim and evidence): In this brain computer interface experiment, we used the Ganglion board and electronic equipment to detect brain waves and how playing musical instruments affects it. We claimed that faster, more involved pieces that demand musicians' focus will cause greater fluctuations and more intense brain waves than slower, more relaxing pieces. We had each musician start by holding their instrument while

not playing it to establish a baseline for their experiment. Then, we had them play a scale followed by a more involved piece of music. This let us compare how brain waves fluctuated within musicians once they were “in the zone” or “out of the zone”. We then had them play a fast and slow piece to analyze the differing effects playing each piece has on the brain.
E (reasoning): When we had the musician play a fast piece, the brain is generally more active, so we saw peaks in brain waves more often when compared to familiar musical progressions and slower pieces. We also saw higher amplitudes for higher-frequency waves like gamma and beta waves compared to the alpha and theta waves associated with the control frame and the scales and slow pieces. We found differences between the two instruments with woodwind versus string that caused different wavelengths to be transmitted, as well as different levels of impedance because of the larger motions in strings. We also saw “in the zone” versus “out of the zone” states of playing transmitting at higher amplitudes in general, showing heightened focus and state of mind.
R: Our results supported our predictions because when playing the instruments, the individual delta, alpha, and beta increased significantly when playing. They also reached their peak when “in the zone” which is when the individual exerted extreme focus into playing the instrument.
U: Uncertainty can be caused from not putting on the BCI headgear properly, not wiping your forehead, or impedance from motions like standing up.
N: 1) How do we analyze the meaning behind ratios of waves beyond individual significance? 2) How do we know that the waves aren’t changing due to outside sources such as other groups’ experiments?

Reference Resources

Learning to play a musical instrument in the middle school is associated with superior audiovisual working memory and fluid intelligence: A cross-sectional behavioral study (**Angel**)
Summary: In this study, the researchers tested their hypothesis that musical experience would strengthen brain development, particularly within audiovisual memory and fluid intelligence. Their experiment used students at 3 middle schools in Italy, half of which participated in a school music program under state curriculum with multiple music lessons a week and collected data about their previous musical experience for consistency. Using LongGold tests including Matrix Reasoning, Jack and Jill Memory test, they covered IQ, visual spatial ability, music ability and sophistication. Results show that the students who have music education perform higher overall compared to students not in music, and that gender is also a variable with females performing better than males on average, likely because of maturation stage differences. Their conclusion is that music training and heightened active memory/visuo-spatial/auditory abilities have a high correlation, although music cannot be described as the singular cause.

https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2019.01198/full (**Karthik**)

Title: Musical Instrument Practice Predicts White Matter Microstructure and Cognitive Abilities in Childhood

Summary: Researchers have believed for a long time that musical instrument practice (especially from a young age) leads to benefits in cognitive abilities. The following study discusses the findings of studying children who practice musical instruments from a young age and their cognitive development. Specifically, the cognitive abilities and development in these children is measured and determined by the difference in the microstructural properties of structures in the brain including the corpus callosum and the superior longitudinal fasciculus between children who practice musical instruments from a young age and children who don’t. The researchers conducted the experiment by surveying different children, both who did not play musical instruments, and also those who played and practiced instruments for different amounts of time per week. The results not only showed a difference in structure for children who play an instrument, it also showed that the number of hours a child practices per week also affects the structure of the superior longitudinal fasciculus. The research supports the researchers' hypothesis, but it is still not clear to say that playing a musical instrument directly causes a change in the child's cognitive development and abilities, since there are so many other factors that contribute to cognitive development. Even though the researchers tried to limit all other confounding factors, correlation does not mean causation.

https://fisherpub.sjf.edu/cgi/viewcontent.cgi?article=1187&context=ur#:~:text=in%20recent%20decades.-,Playing%20a%20musical%20instrument%20has%20been%20shown%20to%20increase%20cognitive,in%20an%20overall%20more%20capable (**Nikhil**)
The article discusses the advantages gained from learning a musical instrument. Stoklosa talks about how research has shown that musicians often have better cognitive skills than other people. These skills include memory, attention, and problem-solving skills. Playing an instrument can also affect the structure of the brain. This can be shown through the fact that musicians usually have a larger corpus callosum, which allows the left and right hemispheres to communicate to each other. This leads to better coordination.

https://www.mdpi.com/2076-3425/13/10/1390 (**Nathan**)
The article reviews research on the effects of music on the brain. The authors synthesized findings from existing research and corroborated them to show how music impacts the brain. They show how music affects neurological processes such as emotional responses, motor coordination, memory encoding, and rehabilitation. The review also looks at how music affects cognitive and emotional development and how it might be applied therapeutically to cure diseases including depression, Parkinson's disease, and stroke. The review also highlights how music enhances cognitive abilities like attention and memory and discusses its role in neuroplasticity suggesting that musical training could boost linguistic skills and auditory processing. The study overall shows the impact of music on brain function and its promising applications in therapeutic settings.

https://scholarworks.calstate.edu/downloads/2n49t693d (**Lucas**)
Title: A Human-Computer Interface for Hands-Free Musical Accompaniment – CSU Long Beach
Summary: A research team from CSU Long Beach has used the same Ganglion boards and OpenBCI technology used in this experiment to design a BCI to control a musical instrument without using their hands using a computer while playing a second instrument. The team used the same EEG equipment that we used in our experiment and combined it with music theory to set up a system that accompanies the musician with chords while they play their physical instrument. The researchers designed a BCI system that used signals from eyes closing and hand movement and their effects on the brain to produce chords to accompany certain musical progressions. Data from brain wave activity is then compared to the root mean square of the data set before the system interprets it and produces accompaniment for the musician accordingly. However, according to the authors, further testing is yet to be done to determine the full scope of this system's practicality and reliability.

https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2021.630829/full (**Michael W**)
This article reviews the correlation between neuroplasticity and musical training. The authors researched how musical training could be used as a model for how our brain adapts and changes to stimuli from playing an instrument. Because musical performance is such a complex activity that requires many different motor systems and sensory inputs such as hearing and touch, it is an excellent framework for reviewing how the brain reorganizes itself in response to such complex tasks. The team's cross-sectional studies of musician's brains have revealed that their brains differ structurally and functionally from non-musicians, particularly in areas that specialize in motor control and auditory processing. The team's longitudinal studies review these changes overtime, demonstrating how different parts of the brain develop throughout musical training; both

cross-sectional and longitudinal studies are integral in studying how the musical brain develops, according to the authors. Future research includes the incorporation of more extensive longitudinal studies that can track changes over longer periods of time in order to gain insight into the progression and eventual stabilization of neuroplastic developments that come with music. However, the authors note that the research can be limited, due to a small sample size, and the experiment's lack of rigor.