International Journal of Psychology and Behavioral Sciences 2015, 5(4): 154-157
DOI: 10.5923/j.ijpbs.20150504.03

Music Training Enhances Cognitive Development: A Longitudinal Pilot Study

Leung Vivien

Department of Music, Hong Kong Baptist University, Kowloon Tong, Hong Kong

Abstract Relationship between music and skills improvement has been a heated research topic for the past two decades. Past research suggested music training can improve different skills such as verbal memory, language skills, and general intelligence. However, past literature experiment only on Caucasian subjects and failed to control quality and quantity of music training and practice. This paper presents a longitudinal study of a single local male subject in Hong Kong, testing the subject on full scale IQ test and fine motor test before and after 16 months of music training. The results support the hypothesis that music training can enhance cognitive development, although the data is collect from one single subject. This study would serve as a pilot guide to a large scale longitudinal study in the future.

Keywords Music Training, Neuroplasticity, Cognitive Development, Early Childhood, Intelligence

1. Introduction

Experience can help shape our behavior and also shape our brain physically (Jäncke, 2009). Studies had begun with animals in 1980s, concluding that stimulus and experience can cause the brain of rats to change physically, forming new neural connections and increasing the relative size of certain brain areas (Kilgard, Pandya, Vazquez, Gehi, Schreiner & Merzenich, 2001). Advanced development of brain imaging in the 1990s (Filler, 2009) allow scientists to observe changes in the human brain as a consequence of training and experience. This ability of the brain to modify its connection is called neuroplasticity.

When one engage in an activity such as tapping your index finger, the neurons (brain cells) in your motor cortex will "fire", sending electrical impulses from your motor area of the brain to your finger, causing your finger to tap. The more one engage in the activity, the more often the neurons fire, quickening the neural transmission and securing the neural connection. More neurons would be recruited to carry out the activity of finger tapping, causing the specific area of the brain responsible for such activity to grow larger.

Professional musicians were often a common subject for researchers to study neuroplasticity. Some researchers stated that professional musicians are the "perfect model…to study neuroplasticity in auditory and motor domains." (Münte, Altenmüler & Jäncke, 2002). Music making require musicians to carry out sequences of complexauditory and motor interactions. The interactions would include reading of scores, moving of finger or arms, listening to notes played, and controlling of attention. The process of music making is highly complex and involves different areas of the brain. Profession musicians engage in music making activities daily for hours, and thus the complex neural pathways in the brain are repeatedly trained, causing the brain to change physically.

Cross-sectional studies on professional musicians discovered that the size of corpus callosum (the bridge between two hemispheres of the brain) is larger in musicians than in non-musicians, and the size of corpus callosum is inversely proportional to the onset age of instrumental training (Schlaug, Jäncke, Huan, Staiger& Steinmetz, 1995). As music training can alter the brain neural connection especially in the auditory and motor areas, scientists were eager to learn how it can change the brain of children. Children have high brain plasticity as the neural networks in the brain are under development and thus experience would change the connection faster than adults (Schellenberg, 2004).

2. Literature Review

Researchers had carried out both cross-sectional and longitudinal studies on relationship between music training and skills development in children. Music training in children has been found to enhance different abilities including motor skills (Schlaug, Forgeard, Zhu, Norton, Norton & Winner, 2009), listening ability (Schlaug, Norton, Overy & Winner, 2005), verbal memory (Ho, Cheung & Chan, 2003), spatial ability (Hetland, 2000), literacy (Ho, Cheung & Chan, 2003) and general intelligence

* Corresponding author:
vivienleungty@life.hkbu.edu.hk (Leung Vivien)
Published online at http://journal.sapub.org/ijpbs

(Schellenberg, 2004).

2.1. Music Training Enhances Skills Development

The studies can be concluded into three main category. Music training is found to have position correlation with (1) motor skills (2) verbal skills and verbal memory (3) executive function and general intelligence.

Music training in present literature usually involves piano or string instruments, involving intense training of finger movements. Training of finger movement would train fine motor skills, causing many different literature reporting a significant improvement of fine motor skills after music training (Forgeard, Winner, Norton & Schlaug, 2008; Schluag et al., 2009). A longitudinal study by Hyde and colleagues (2009) on 31 subjects of six to seven years old shows that subjects with an extra 30-minute private keyboard lesson per week performs better in finger motor sequencing test than control subjects after 15 months of training.

Music and language have many similarities, for example, sentences in language are governed by syntax while phrases in music are governed by harmonic progression (Schön, Magne & Besson, 2004). Neurologically, pitch recognition in music and language also activates similar brain areas (Schön, Magne & Besson, 2004). Literature observed significant improvement of verbal skills and verbal memory in relation to music training (Chan, Ho & Cheung, 1998; Moreno, Marques, Santos, Santos, Castro & Besson, 2009). Children who had music training perform better in auditory discrimination, vocabulary and verbal reasoning tasks than control subjects in a cross sectional study of 59 subjects (Forgeard, Winner, Norton & Schlaug, 2008).

Music is a complex activity that involves many areas of the brain. Intensive music training after a prolonged period can improve both cognitive development and executive function. Experimental results have shown that general intelligence and cognitive skills improve after music training (Corigall & Trainor, 2011; Schellenberg, 2004). Moreno et al. (2009) used a longitudinal design to conclude that intense musical training, defined as two 75-minue lessons per week, can significantly improve brain electrophysiological activity and Intelligence Quotient (IQ), which tests verbal comprehension, perceptual reasoning, working memory, reading and speech abilities.

2.2. Cross-sectional or Longitudinal Study?

While cross sectional studies are easier for researchers to collect data from a large number of subjects, researchers are not able to control the quality and quantity of past music training or practice. Although music training intensity is an important variable, it is also important to control for practice intensity as it would affect skills development. After 24 months of music training, high practicers (children practicing for 2-5 hours per week) improve in motor skills while low practicers (children practicing for 1-2 hours per week) showed no significant improvement from control subjects (Schlaug et al., 2009).

Longitudinal studies have an advantage over cross-sectional studies, apart from controlling variable such as quality and quantity of music training. Longitudinal studies would be able to prove causal relationship between music training and any changes or improvement in skills in subjects. Music training and improvement of skills in cross-sectional studies can only prove a correlational relationship but longitudinal studies can prove that music training can cause improvement of specific skills across time.

2.3. Research Gap to Fill

Past research literature had been very comprehensive, providing sound evidence with cross-sectional and longitudinal studies in different skills that benefit from music training. However, controlling music training and practice quality and quantity were difficult for researchers. When attempting to provide identical music training for subjects, free music training failed to motivate subjects to attend classes regularly and practice at home (Bilhartz, Bruhn & Olson, 1999). Funds were also an issue for researchers to provide free music training for subjects (Schellenberg & Winner, 2011), thus subjects would need to seek music training individually and researchers could not control quality of music training.

Nearly all past research used Caucasian children as subjects, with the exception of studies by Chan, Ho & Cheung (1998) and Ho, Cheung & Chan (2003) on how music training enhances verbal memory. This study serves as a pilot guide for attempts to experiment on Asian population, testing if western music training on string instrument would enhance cognitive development in children growing up in an Asian city as well as those growing up in Western culture.

3. Method

This study is a longitudinal study of a single male subject in Hong Kong. The male subject started music training at age 5 years 10 months, receiving training in violin playing for one hour per week in a class basis. The Hong Kong Wechsler Intelligence Scale for Children (HK-WISC) and Bruininks-Oseretsky Test (BOT) of motor proficiency (fine motor composite test) was administered at age 5 years 11 months, one month after the music training commenced.

At 6 years 5 months, music training intensified, in which the subject receive a weekly one-hour group class and a weekly 45-minute one-on-one private class. At 7 years 3 months, the subject was tested using the HK-WISC and BOT fine motor composite test again. A detailed log of everyday practice record had been kept by the subject's parents, controlling practice quantity.

4. Results

HK-WISC test results when the subject was 5 years 11 months showed strong abilities in verbal comprehension and perceptual reasoning skills, and average processing speed and working memory. Fine motor composite test of Bruininks-Oseretsky Test of motor proficiency (BOT) showed that at 5 years 11 months, the subject displayed response speed equivalent to 4 years 2 months, which the performance is below average for males his age, placing his overall fine motor skill at 50th percentile.

The subject was tested again at 7 years 3 months, after receiving music training for 16 months, using the same tools of measurement. The subject showed improvement in both processing speed and working memory in HK-WISC test. Results from the fine motor composite test of BOT also showed improvement after 16 months of music training. His response speed improved compared to his previous test, although performance is still below his age requirement, placing his overall fine motor skill at 54th percentile. Results of both tests are listed in the appendix.

5. Discussion

This longitudinal study of a single male subject showed significant improvement in the processing speed and working memory subtests of the IQ test and improvement in fine motor skill after 16 months of music training. Results in this study shows that music training can enhance processing speed, working memory and fine motor skills.

The improvement in the subject can be attributed to (1) music training (1 hour 45mintues per week) and (2) intense practicing. Children practicing for 2-5 hours per week showed significant improvement in motor skills development (Shclaug et al., 2009), and the subject of this study practice high very high intensity, averaging to 10 hours of practice a week.

Music training enhanced different skills in subject in this study. The improvements can be divided into two categories: (1) domain-specific transfer; and (2) domain-general transfer (Forgeard, Winner, Norton & Schlaug, 2009). Domain-specific transfer refers to skills that relates directly to music training, in this case, the fine motor skills. Music training involves training in finger movement and when finger movement skills improve, it also improves the fine motor skills. Domain-general transfer refers to skills that are not directly related to music training, in this case, processing speed and working memory. Music training requires multiple areas of the brain to collaborate when playing an instrument. Playing instrument also requires focus and attention on scores and motor skills. Prolonged training caused cognitive skills such as processing speed and working memory to improve, and the improvement can be categorized as domain-general transfer.

5.1. Possible Error

This study used a single subject to provide a background information for further longitudinal study of a larger scale. Music training in the subject provided insight on how quality and quantity of both music training and practice can be controlled.

However, owing to the small data sample, the results might show possible error. This study results might not represent general population of preschool children as this child was a gifted child, already reaching 99th percentile of the population of the same age at a 95% confidence interval. The possible errors all provide a way of improving the study when carried out at a larger scale in the future.

5.2. Further Research

In this research, music training is provided by an experienced music trainer who had attained a Fellowship from the Royal Schools of Music, thus fully qualifying the music teacher to provide music training to children. Although this study serves as a pilot study, this music trainer will be the one providing identical music training for future longitudinal study, controlling the quality of music training.

Appendix

HK-WISC test score of subject at age 5 years 11 months (5:11) and at age 7 years 3 months (7:3)

Indexes	Subtest	Scaled score (5:11)	Scaled score (7:3)
Verbal Comprehension	Information	18	19
	Similarities	19	19
	Vocabulary	14	15
	Comprehension	14	15
Perceptual Reasoning	Picture Completion	15	15
	Picture Arrangement	16	17
	Block Design	13	15
	Object Assembly	16	16
Processing Speed	Coding	11	14
Working Memory	Arithmetic	11	13

Bruininks-Oseretsky Test of motor proficiency (fine motor composite): test score of subject at age 5 years 11 months and at age 7 years 3 months

Subtest	Score at 5 yr 11 mth, measured as age equivalence	Score at 7yr 3 mth, measured as age equivalence
Response Speed	4yr 2 mth	6 yr 11 mth
Visual-Motor Control	7 yr 5 mth	8 yr 10 mth
Upper Limb Speed and Dexterity	7 yr 2 mth	7 yr 8 mth
Fine Motor Composite (percentile rank)	50th	54th

REFERENCES

[1] Bilhartz, T. D., Bruhn, R. A., & Olson, J. E. (1999). The effect of early music training on child cognitive development. Journal of Applied Developmental Psychology, 20(4), 615-636.

[2] Chan, A. S., Ho, Y. C., & Cheung, M. C. (1998). Music training improves verbal memory. Nature, 396(6707), 128-128.

[3] Corrigall, K. A., & Trainor, L. J. (2011). Associations between length of music training and reading skills in children. Music perception, 29(2), 147-155.

[4] Filler, A. (2009). MR Neurography and Diffusion Tensor Imaging: Origins, History & Clinical Impact of the first 50,000 cases with an Assessment of Efficacy and Utility in a Prospective 5,000 Patient Study Group. Neurosurgery, 65(4 Suppl), A29–A43. doi:10.1227/01.NEU.0000351279.78110.00.

[5] Forgeard, M., Winner, E., Norton, A., & Schlaug, G. (2008). Practicing a musical instrument in childhood is associated with enhanced verbal ability and nonverbal reasoning. PloS one, 3(10), e3566.

[6] Ho, Y. C., Cheung, M. C., & Chan, A. S. (2003). Music training improves verbal but not visual memory: cross-sectional and longitudinal explorations in children. Neuropsychology, 17(3), 439.

[7] 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, 29(10), 3019-3025.

[8] Jäncke, L. (2009). The plastic human brain. Restorative neurology and neuroscience, 27(5), 521-538.

[9] Kilgard, M. P., Pandya, P. K., Vazquez, J., Gehi, A., Schreiner, C. E., & Merzenich, M. M. (2001). Sensory input directs spatial and temporal plasticity in primary auditory cortex. Journal of neurophysiology, 86(1), 326-338.

[10] Moreno, S., Marques, C., Santos, A., Santos, M., Castro, S. L., & Besson, M. (2009). Musical training influences linguistic abilities in 8-year-old children: more evidence for brain plasticity. Cerebral Cortex, 19(3), 712-723.

[11] Münte, T. F., Altenmüller, E., & Jäncke, L. (2002). The musician's brain as a model of neuroplasticity. Nature Reviews Neuroscience, 3(6), 473-478.

[12] Schellenberg, E. G. (2004). Music lessons enhance IQ. Psychological Science, 15(8), 511-514.

[13] Schellenberg, E. G., & Winner, E. (2011). Music training and nonmusical abilities: introduction. Music Perception, 29(2), 129-132.

[14] Schlaug, G., Forgeard, M., Zhu, L., Norton, A., Norton, A., & Winner, E. (2009). Training-induced Neuroplasticity in Young Children. Annals of the New York Academy of Sciences, 1169(1), 205-208.

[15] Schlaug, G., Jäncke, L., Huang, Y., Staiger, J. F., & Steinmetz, H. (1995). Increased corpus callosum size in musicians. Neuropsychologia, 33(8), 1047-1055.

[16] Schlaug, G., Norton, A., Overy, K., & Winner, E. (2005). Effects of music training on the child's brain and cognitive development. Annals of the New York Academy of Sciences, 1060(1), 219-230.

[17] Schön, D., Magne, C., & Besson, M. (2004). The music of speech: Music training facilitates pitch processing in both music and language. Psychophysiology, 41(3), 341-349.