STUDIA UBB MUSICA, LXVIII, 1, 2023 (p. 185 – 202)
(RECOMMENDED CITATION)
DOI: 10.24193/subbmusica.2023.1.11

THE TRANSFER EFFECTS OF LEARNING MUSIC AND THEIR UNDERLYING CAUSES

TÍMEA SZŰCS[1]

SUMMARY. Since the second half of the 20th century, there has been an increasing number of studies on the transfer effects of music learning. There is considerable scientific research in both the national[2] and international literature[3] to support the transfer effects of music learning in different areas of life. In Hungary, these researches started at the instigation of Zoltán Kodály, who saw the observable effects of learning music in several areas. He also considered it important to present scientifically supported results, which is why research on the transfer effect marked by the name of Klára Kokas was started in Hungary. While previously the phenomenon could only be described based on cross-sectional or longitudinal surveys, thanks to technological development we could observe the active areas of the brain during various activities, during which we can interpret the causes of the transfer effects affecting different areas supported by MRI images[4]. During my presentation, I will outline the results of these researches, objectively confirming the reasons behind the transfer effects created by learning music. This gives us the opportunity to learn about the results of research that started from Kodály's foundations and is nowadays showing an increasingly complex picture.

Keywords: transfer effects of music learning, neurological background of music learning, music education

[1] *University of Debrecen, Institute of Educational Studies and Cultural Management, assistant professor, szucstimea77@gmail.com*

[2] Szűcs, Tímea. *Alapfokú művészeti iskola, egy esélynövelő iskolatípus. (Primary art school, a school type that increases students' chances).* Debreceni Egyetemi Kiadó, Debrecen, 2019.

[3] Schellenberg, E. Glenn. Long term positive associations between music lessons and IQ. In: *Journal of Educational Psychology*, 98. vol. 2. pp. 457–468, 2006.

[4] Schewe, F. Philip. *Music Improves Brain Function*. Available: https://www.livescience.com/7950-music-improves-brain-function.html,2009. (2022.05.27.)

Introduction

The 21st century is permeated by the fascination of using digital devices. This also means that the way information is processed and sifted is changing, with spatial-visual processing playing an increasingly important role in information processing. At the same time, the human nervous system is also undergoing transformation, as environmental influences affect the open system of our brain. The age group that Prensky[5] calls *digital natives* has meet many new influences, because of which they react differently, make decisions in a manner other than the age group that preceded them, the digital immigrants. Since they receive ready-made images through technical means, imagination has been pushed into the background. As a result, they do not learn to create a picture from a linguistic sequence, which weakens text comprehension, since it is based on imagination. Due to less movement, their sensorimotor system develops more slowly and often operates more poorly. This is also contributed to by neglecting to participate in active recreation and by giving passive experiences prominence. Since the coordination of visual experience, movement, and the developed balance system are essential for cognitive function, difficulties may arise for children later in life, because their neurological system did not receive enough stimuli for its proper development[6].

With spatial-visual abilities and the holistic approach coming to the foreground, the right hemisphere of our brain came into a dominant position. This hemisphere is responsible for functions like the imagination, understanding music, spatial-visual abilities, humor, and quick solutions. It is also necessary for teachers to adapt to these changes and use methods that require comprehensive visual thinking. Sports that require two-handed movement, strategy games, sounds-images-movements with verbality, and the arts can help in this. In my current study, I will talk about the transfer effects of learning music and the causal relationships behind them, through which we can understand why it is worthwhile to encourage children to take part in learning music.

[5] Prensky, Marc. Digital Natives, Digital Immigrants. In: *On the Horizon*. MCB University Press, vol. 9, 2001.

[6] Gyarmathy, Éva. A digitális kor és a sajátos nevelési igényű tehetség. (The digital age and the specail education need talent). In: *Fordulópont*, 51, 2011, pp. 79–88.

There are numerous studies on the transfer effects of music learning in both the national[7] and international literature[8]. While at the beginning, researchers could only observe and describe the phenomenon, with the development of technology (PET, fMRI), it has become possible to learn about the causes and processes that create this effect. First, I will briefly describe the areas in which the transfer effects of music learning can occur, and then explore the underlying neurological causes.

A brief overview of the transfer effects of music learning

According to Laczó[9], the transfer effect refers to the fact that the learning mechanisms developed during the mastery of one material can also help in the acquisition of another, similar material, thus producing better learning results. In connection with the transfer effects of music learning, we can distinguish transfer effects related to subjects, and we can also observe the development of areas that can be well utilized in learning any subject or play an important role in success outside of school.

Zoltán Kodály's name is recognized not only in Hungary, but worldwide. This is supported by the fact that the music education program referred to as the "Kodály method" was included in the hungaricum list (a list of all things belonging to Hungarian culture and being strictly of Hungary origin) in 2017. As a reason for its induction into hungaricum, we read: "Kodály's music pedagogy concept therefore goes far beyond the narrower field of music education: its overall social impact in Hungary today is as unparalleled as it was at the time of its birth (the 1930s) and its development (the 1950s, 1960s)"[10]. Zoltán Kodály observed the following during his observation of the students attending the singing and music elementary school: "[...] in all subjects, they are better than pupils in schools with two singing lessons a week [...]. It is undeniable that daily music-making and singing is mentally invigorating for children, who become more receptive to other subjects." [11]

---

[7] Harmat, László and Tardy, József. *A gyógyító zene (Healing music).* Új Ember Kiadó, Budapest, 2013.
Szűcs, Tímea, *Alapfokú művészeti iskola, egy esélynövelő iskolatípus. (Primiary art school, a school type that increases students' chances).* Debreceni Egyetemi Kiadó, Debrecen, 2019.

[8] Schellenberg, E. Glenn. Long term positive associations between music lessons and IQ. In: *Journal of Educational Psychology*, 98. vol. 2, 2006, pp. 457–468.
Wan, Catherine,Y., Schlaug, Gottfried, Music making as a tool for promoting brain plasticity across the life span, in: *Neuroscientist,* 16, 2010, pp. 566–577.

[9] Laczó, Zoltán. Zenepedagógia és társadalom (Music pedagogy and society). In: *Hang és lélek*, Magyar Zenei Tanács, Budapest, 2001.

[10] http://www.hungarikum.hu/hu/content/kodály-módszer (2023.01.23)

[11] Kodály, Zoltán. *Visszatekintés (Looking back)*, Zeneműkiadó Vállalat, Budapest, 1982, pp. 588-589.

But Zoltán Kodály did not stop here. He initiated research on the transfer effects of music education in Hungary. He considered it important to present scientifically supported findings. Thus, the transfer effect research led by Klára Kokas was started at that time here at home, and continues to this day, as it continuously produces new and fresh results.

During Klára Kokas' research[12], physical dexterity exercises (dynamic coordination exercises, target drills, gymnastic exercises via mimicking forms displayed by stick figures, freestyle rhythm exercises) were carried out among elementary school children with a music department and normal curriculum. In their studies, Barkóczi and Pléh[13] observed movement coordination, the development of fine motor skills, and movement in space while performing various dances and games. The research showed that children studying music performed better than children studying other subjects. As we search for the causes, it is worth considering that musical activity requires multiple actions arranged in a hierarchical order to be executed with precise timing, sequencing, and spacing. Therefore, children perform coordinated and controlled moves while singing and playing instruments. Knowing this, we will be able to see the correlations referring to the improved performance of children learning music which was experienced during physical skill tests.

It is possible that behind the observed improved performance in reading and spelling there might be more developed hearing of speech sounds. According to researchers, this hearing of speech (i.e.- phonological awareness) is important in the early stages of reading[14]. Distinguishing the pitch of musical notes is also essential for reading[15]. Moreover, to correctly isolate and identify notes, one must know how to listen well. Gromko[16] believes that listening comprehension develops faster because of playing an

[12] Kokas, Klára. *Képességfejlesztés zenei neveléssel (Skill development with music education).* Zeneműkiadó, Budapest, 1972.

[13] Barkóczi, Ilona, Pléh, Csaba, *Kodály zenei nevelési módszerének pszichológiai hatásvizsgálata. (The psychologicalimpact assessment of Kodály's musical education method),* Kodály Intézet, Kecskemét, 1977.

[14] Anvari, Sima H., Trainor, Laurel J., Woodside, Jennifer, Levy, Betty, Ann, Relations among musical skills, phonological processing, and early reading ability in preschool children, in: *Journal of Experimental Child Psychology,* 83. vol. 2, 2002, pp. 111–130.
Janurik, Márta, A zenei képességek szerepe az olvasás elsajátításában. (The role of musical skills in reading acquistion). In: *Magyar Pedagógia*, 108. vol. 4, 2008, pp. 289–317.

[15] Moreno, Sylvain, Marques, Carlos, Santos, Andreia, Santos, Manuela, Castro, Sao, Luís, Besson, Mireille. Musical training influences linguistic abilities in 8-year-old children: more evidence for brain plasticity. In: *Cerebral Cortex,* 19. vol. 3, 2009, pp. 712–723.

[16] Gromko, Joyce, The effect of music instruction on phonemic awareness in beginning readers, in: *Journal of Research in Music Education*, 53. vol. 3, 2005, pp.199–209.

instrument. In their research, Thompson, and colleagues[17] found that adults who had learned music as children were more effective at identifying emotions conveyed by speech (e.g., anger or sadness) in both familiar and unfamiliar languages. Thompson and his colleagues therefore believe that common brain processes take place when processing speech prosody and music.

The link between foreign language skills and music learning has been confirmed by several studies. The perception and processing of speech, pronunciation, word stress, and sentence stress all show a positive correlation with learning music[18]. The connection between learning music and acquiring better verbal memory was supported by researchers conducting studies among boys aged 6-15[19]. Wong and his colleagues, with the help of an EEG, investigated the processing of pitch changes, during which they found that music students can better process these changes. In another experiment, native English-speaking subjects learned familiar English words that had different meanings based on their intonation. For this experiment, the recording of the words was done with the help of music studies[20].

According to Kells[21], it is possible to develop mathematical thinking at an early age through music. Rhythm, for example, rhythmic patterns, tempo, arrangement of sound patterns, and sheet music all aid in the mastery of mathematical concepts. Recognizing and understanding musical symbol units, understanding the relationships between symbols, and the development of manipulation with symbols can help in mathematics education as well.

---

[17] Thompson, William, Forde, Schellenberg, E. Glenn, Ilie, Gabriela, Decoding speech prosody: Do music lessons help? in: *Emotion,* 4. vol. 1, 2004 pp. 46–64.

[18] Milovanov, Riia, Huotilainen, Minna, Valimaki, Vesa, Esquef, Paulo, A. A., Tervaniemi, Mari, Musical aptitude and second language pronunciation skills in school-aged children: Neural and behavioral evidence, in: *Brain Research,* 1194. pp. 81–89, 2008.

Milovanov, Riia, Pietila, Paivi, Tervaniemi, Mari, Esquef, Paulo A. A., Foreign language pronunciation skills and musical aptitude: A study of Finnish adults with higher education, in: *Learning and Individual Differences,* 20. vol. 1, 2010, pp. 56–60.

Slevc, L. Robert, Miyake, Akira, Individual differences in second language proficiency: does musical ability matter? in: *Psychological Science*, 17. vol. 8. pp. 675−681, 2006.

Tallal, Paula, Gaab, Nadine, Dynamic auditory processing, musical experience and language development, in: *Trends in Neuroscience,* 29, vol. 7, 2006, pp. 382−390.

[19] Ho, Yim-Chi, Cheung, Mei-Chun, Chan, Agnes, S., Music training improves verbal but not visual memory: Cross-sectional and longitudinal explorations in children. In: *Neuropsychology*, 17. vol. 3, 2003, pp. 439–450.

[20] Wong, Patrick, C. M., Perrachione, Tyler, Learning pitch patterns in lexical identification by native English-speaking adults, in: *Applied Psycholinguistics,* 28. vol. 4. 2007, pp. 565–585.

Wong, Patrick, C. M., Skoe, Erika, Russo, Nicole, M., Dees, Tasha, Kraus, Nina, Musical experience shapes human brainstem encoding of linguistic pitch patterns, in: *Nature Neuroscience,* 10. vol. 4, 2007, pp. 420–422.

[21] Kells, Deanne, The Impact of Music on Mathematics Achievement. http://www.kinder musik.com/Classes/Downloads/ ImpactOfMusicOnMath.pdf, 2009.

According to the research of Gombás and Stachó[22], the total math score was significantly tied to the total music score. Schmithorst and Holland[23] also found evidence of the relationship between music and mathematics. The basis of the connection between the two areas is that playing from sheet music requires skills that are related to various mathematical operations, e.g., meter and rhythm. According to Nisbet[24], there is a significant relationship between the symbols embodying the temporal arrangement of music and the mathematical symbols associated with fractions. Spelke[25] tested students in identifying the geometric properties of visual shapes and found that children who took music lessons performed better than children who did not take music lessons. According to Wenger's research[26], the use of cortical neurons that are activated during musical practice also strengthens the cortical areas involved in mathematical thinking.

Schumacher and Altenmüller[27] found a positive relationship between music learning and intellectual ability, attention, and perseverance. Barkóczi et al.[28] noticed that memory was strengthened in relation to movement, vision, and hearing, and that the attention span when correlated to latter could also be increased.

Music contributes positively to our physical and mental health by relieving stress. Good physical and mental health are necessary for building

---

[22] Gombás, Judit, Stachó, László, *Matematikai és zenei képességek vizsgálata 10-14 éves gyerekeknél (Examination of mathematical and musical abilities in children aged 10-14)* Available: elib.kkf.hu/okt_publ/tek_2006_35.pdf, 2004. (2015.06.22.)

[23] Schmithorst, Vincent, J., Holland, Scott, K., The effect of musical training on the neural correlates of math processing: a functional magnetic resonance imaging study in humans, in: *Neuroscience Letters,* 354, 2004, pp. 193–196.

[24] Nisbet, Steven, Mathematics and music, in: *The Australian Mathematics Teacher*, 47. vol. 4. 1991, pp. 4–8.

[25] Spelke, Elizabeth, Effects of Music Instruction on Developing Cognitive Systems at the Foundations of Mathematics and Science, in: Asbury, Carolyn, Rich, Barbara eds., *Learning, Arts, and the Brain*. Dana Press, New York, 2008, 17–49.

[26] Wenger, Win, Wenger, Susan, Honey, Training music sight-reading and perfect pitch in young children, as a way to enhance their intelligence, in: *Journal of the Society for Accelerative Learning and Teaching*, 15. 1990, vol. 77–89.

[27] Schumacher, Ralph, *Bessere Noten durch Musik?* available: http://www.lernwelt.at/downloads/machtmozartschlaudrralphschumacher.pdf, 2014. (2014.08.12.) Altenmüller, Eckart. *Musikalsiches Lernen und Hirnentwicklung* Available: http://www.clubofrome.de/schulen/schulen/downloads/altenmueller_musikalisches_lernen_hirnentwicklung.pdf, 2006. (2014.08.12.)

[28] Barkóczi, Ilona, Pléh, Csaba. *Kodály zenei nevelési módszerének pszichológiai hatásvizsgálata. (The psychologicalimpact assessment of Kodály's musical education method),* Kodály Intézet, Kecskemét, 1977.

an efficient and healthy society. According to Gick[29], biological, psychological, and social factors contribute to health. For example, the results showed that singing has a clear long-term positive effect on breathing and a short-term positive effect on the immune system. According to a 2010 study by Clift et al.[30], singing in a choir has several beneficial health effects. It can help increase lung capacity, correct posture, act as a physical activity and relieve stress. Excerpts on the topic can also be found in the study by Dingle et al. [31] examining the social and mental health benefits of choral singing among disadvantaged adults, in the work of Clift et al. [32] among university students, and in Young's study[33] examining the benefits of community singing groups among adults with cancer.

Kreutz et al.[34] also observed physiological and psychometric mechanisms of action. The participants in the study reported positive changes in psychological well-being and their emotional state. In addition, they were able to demonstrate the immunogenetic effects of group singing. Group singing helps maintain the balance of the neurohumoral system, while increasing the production of sIgA immunoglobulin, which protects against upper respiratory tract infections. It was also observed that the body's cortisol level decreased, and the immune system worked better as a result. But these effects are significant only in the case of active participation, simply listening has little effect.

In all the great civilizations, music was believed to have a personality-forming effect. Regular practice teaches students discipline, perseverance, self-control, hard work, gives them a sense of purpose, sense of responsibility and personal commitment, and bolsters their willpower – all qualities that can be utilized in other areas of life. Self-expression and self-actualization while making

[29] Gick, Mary, L., Singing, health and well-being: A health psychologist's review, in: *Psychomusicology: Music, Mind & Brain,* 21. vol. 1-2, 2011, pp.176-207.

[30] Clift, Stephen, Hancox, Grenville, Morrison, Ian, Hess, Barbel, Kreutz, Gunter, Stewart, Donald, Choral singing and psychological wellbeing: Quantitative and qualitative findings from English choirs in a cross-national survey. in: *Journal of Applied Arts and Health*, 1. vol. 1, 2010, pp.19-34.

[31] Dingle, Genevieve, A., Brander, Christopher, Ballantyne, Julie, Baker, Felicity. A., 'To be heard': The social and mental health benefits of choir singing for disadvantaged adults, in: *Psychology of Music*. 40. vol. 3, 2012, pp. 1–17.

[32] Clift, Stephen, M., Hancox, Grenville. The perceived benefits of singing: findings from preliminary surveys of a university college choral society. In: *The Journal of The Royal Society for the Promotion of Health***,** 121. vol. 4, 2001, pp. 248-256.

[33] Young, Laurel, The potential health benefits of community-based singing groups for adults with cancer, in: *Canadian Journal of Music Therapy*, 15. vol. 1, 2009, pp. 11-27.

[34] Kreutz, Gunter, Bongard, Stephan, Rohrmann, Sonja, Grebe, Dorothee, Bastian, H. Günther, Hodapp, Volker. Does singing provide health benefits? In: *Proceedings of the 5th Triennial ESCOM Conference*. 2003, pp. 216-219.

music can be a source of joy and flow. Enduring success and failure also train a musician's character. Continuous self-evaluation is necessary during practice and competitions, helping the student to know and appreciate himself more and more. Therefore, playing music has a character-shaping and value-transmitting effect, which also helps moral, aesthetic and community education.

Playing music together develops a sense of belonging, self-sacrifice, and the ability to subordinate individual interests. In this way, musicians become part of a small community that helps them integrate into the larger community and society. Playing music together improves social skills, increases group cohesion, develops communication, cooperation, problem solving and empathy.

When examining the transfer effects of music education, it is important to note the effects of music and instrument playing on structural and functional changes, neurological processes, and brain plasticity. The actions related to playing music are all complex actions that are related to several cognitive, affective, and psychomotor areas. The emerging neural connections are the basis of the transfer effects.

Music learning and brain activities

Learning music also affects the higher levels of cognitive function, so it is of outstanding importance to intellectual development. For this reason, it is worth reevaluating the place of music in education, early development, and rehabilitation. The tools of cognitive neuroscience give us the opportunity to develop the most effective methods, carry out their impact assessment and their implementation. It is worth becoming acquainted with the modern imaging procedures that allow us to learn more about the changes that take place in the brain when learning music.

Functional magnetic resonance imaging (fMRI) is a procedure that uses variations in a magnetic field to monitor functional changes in the brain over time. All of this is based on the BOLD method (Blood Oxygen Level Dependent), with which the functional centers responsible for sensory, motor, and cognitive responses, such as visual, auditory, motor and somatosensory centers can be visualized[35]. Another important modern functional imaging

[35] Juhász, Gabriella. Funkcionális mágneses rezonanciás képalkotó vizsgálatok a fájdalom kutatásban. (Functional MRI examinations in pain research), Semmelweis Egyetem, Gyógyszerhatástani Intézet MTA-SE-NAPB Genetikai Agyi Képalkotó Migrén Kutató csoport, 2015.
Vandulek, Csaba. *A modern funkcionális keresztmetszeti képalkotás integrálása központi idegrendszeri tumorok 3D alapú sugárkezelési eljárásaiba. (The integration of modern functional crossection imaging into 3D-based radiation treatment procedures of tumors in the central nervous system)* PhD dissertation, Pécs, 2016.

procedure is positron emission tomography (PET), which can be used to obtain a three-dimensional image of a specific area of the body. This procedure displays the various functional characteristics of organs and tissues (e.g., blood flow, metabolism) at a given moment.

Since different areas of our brain are activated while we do different activities, we can with the help of these procedures observe which areas are active during the performance of which given activity (reading, singing, etc.). It is therefore possible to identify the brain center responsible for that activity. When playing an instrument, almost all parts of the brain are activated, especially the areas of the cerebral cortex responsible for auditory, motor and visual functions. During regular practice, these functions of the brain are strengthened, which can be useful in other activities as well. For, Music is a multisensory experience coming through multiple channels: a close unity of auditory, tactile, vestibular, and kinesthetic stimuli. The fetus reacts to music as early as the 24th week. During active musical activities, for example, musicians perform complex movements, all the while paying attention to rhythm and melody, constantly checking their acoustic, tactile, visual, kinesthetic, and proprioceptive feedback of their play. For, making music is a complex task, requiring you to pay attention to several systems simultaneously. What is being played and what will follow, the notes of a piece heard at a given moment, and even individual performance must be reviewed and modified, depending on what the other musicians are playing. The result: making music takes enormous amounts of intense concentration. This may be the reason for increasing one's attention span, one of the previously mentioned transfer effects.

Behind the improved memory of musicians lies the fact that they can recall a single memory in several different ways, since they must already coordinate different sensory areas while playing music. The paths of visual, auditory, and tactile perception are intertwined with cognitive activity, and it is this multiple retrieval path that gives musicians improved memory in other areas of life as well (conceptual, emotional, vocal, text contexts).

Schewe[36] came to the realization that even one or two years of learning music with the help of an instrument results in a greater ability to focus and a sharper memory. However, this does not apply to passively listening to music. The reason for this is that playing an instrument requires coordinated auditory and motor skills, which requires intense concentration and a good memory. Thus, the areas of the brain responsible for these skills

[36] Schewe, F. Philip. Music Improves Brain Function. available: https://www.livescience.com/7950-music-improves-brain-function.html, 2009. (2023. 05.27.)

develop faster. According to Hebb[37], if one neuron "turns on" another due to frequently repeated actions, the connection between them is strengthened. In the words of Löwel and Singer[38]: "neurons that fire together wire together".

It is worth distinguishing between listening to music and actively playing music: fine motor skills are essential during music playing, which requires both hemispheres of the brain. After all, mathematical and linguistic accuracy (e.g., rhythm) is associated with the left hemisphere of the brain, and creativity and innovation (e.g., melody) with the right hemisphere. Since both brain hemispheres are involved in playing music, the cortical body between them - which connects the two hemispheres - is strengthened. In this way, the transmission of stimuli between hemispheres happens faster and in a more diverse way. This increased activity also increases the physical size of the cortical body. In musicians and music students, this may result in a more effective and creative ability to solve problems. However, this connection between the two hemispheres does not exist when listening to music.

When playing music, the brain simultaneously processes the emotional and formal message of the music. This helps music students perform well in other areas of life where emotional and cognitive analysis must be performed simultaneously (observation of details, strategic planning).

One explanation for the transfer effects of music education is the overlapping functional areas of the cortical networks (music and other activities such as reading, speech, language development, mathematics). Significant improvement was found in the development of three main brain structures: the areas of fine motor skills, of auditory processing, along with the cortical body connecting the right and left hemispheres[39].

The varied effects of playing music influence the development of networks responsible for reason and emotion, planning and thinking, and the planning and execution of movement.

The effects of musical activity are mostly associated with the development of command functions. These are in turn tightly connected to the anterior prefrontal cortex, the area responsible for attention, working memory, mental planning, and the control of motor activities[40].

---

[37] Hebb, Donald, O. *The Organization of Behavior: A Neuropsychological Theory*, John Wiley & Sons, Inc., New York, 1949.

[38] Löwel, Siegrid, Singer, Wolf. Selection of Intrinsic Horizontal Connections in the Visual Cortex by Correlated Neuronal Activity, in: *Science*, 255. vol. 5041, 1992, pp. 209-212.

[39] Hyde, Krista, L., Lerch, Jason, Norton, Andrea, Forgeard, Marie, Winner, Ellen, Evans, Alan, C., Schlaug, Gottfried. The Effects of Musical Training on Structural Brain Development. In: *The Journal of Neuroscience*. 29 vol. 10, 2009, pp. 3019–3025.

[40] Altenmüller, Eckart, Schlaug, Gottfried. Music, brain, and health: Exploring biological foundations of music's health effects, in MacDonald, Rajmond, Kreutz, Gunter & Mitchell, Laura eds., *Music, health and wellbeing*. Oxford University Press, New York, 2012, pp. 11-24.

According to József Hámori[41], playing music requires the coordinated operation of both hemispheres of the brain. As was previously addressed, both hemispheres are responsible for operating different parts of the body and instigating different functions. Associated with the right hemisphere is the movement of the left hand (and leg); musical communication skills, creativity, memorization, and recall skills; along with musical abilities like timbre, perfect pitch, recognition, and isolation of harmonies; spatial perception and vision; abstract thinking, creativity. Within creativity lies being receptive to new things, grasping musical concepts. Processing emotions and being sensitivity to non-verbal influences are also directed from this hemisphere. From here comes the enjoyment of music. Finally, it is the associative region of the brain, directing the ability to memorize and recall melodies. The left hemisphere is responsible for the movement of the right arm and leg; for speaking skills (language center, e.g.: speech comprehension, speech analysis), perception of time (sense of rhythm related to musicality), logical thinking, (playing a musical instrument after receiving musical training, the tasks and techniques used for becoming learned in music)[42].

The brain must also be in harmony when music is to be played. When reading sheet music, visual signals must be decoded, involving the areas controlling eye movement, visual perception, and signal-sound association. In playing an instrument, it is essential when playing an instrument to process the proprioceptive stimuli responsible for posture, and the tactile stimuli that aid in handling an instrument. Also, two other elements must not be forgotten: processing the coordinated planning and execution of large and fine movements, along with continually comparing the notes from the sheet music with those being played.

The maturing of the cognitive processes necessary to connect distant regions of the brain is preceded by the changes that promote coordinating the brain processes responsible for gross and fine motor skills with the modalities of perception (touch, hearing, vision).

To give an idea of the complex and coordinated activity required for making music, I will show a few concrete examples. According to Hüther[43], a German developmental neuropsychologist and brain researcher: “One of the most wonderful physical learning exercises is singing. Meanwhile, the

[41] Hámori, József. *Az emberi agy aszimmetriái (The asymmetry of human brain).* Dialóg Campus Kiadó, Budapest-Pécs, 2002.

[42] Hámori, József. Az emberi agy plaszticitása (The plasticity of human brain). In: *Magyar Tudomány*, 50. vol. 1, 2005, pp. 43-51.

[43] Hüther, Gerald. Digitális média és gyermeki agy, Virtuális világok bűvöletében (Digital media and children’s brain. Under the charm of virtual reality). In: *Élet és Tudomány*, 64. vol. 13, 2009, pp. 405-408, 405.

child's brain must modulate the vocal cords in such a virtuoso way that the right sound comes out exactly. This is the best possible fine motor exercise, and at the same time it is a condition for all subsequent, highly differentiated ways of thinking."

According to Fekete[44], complex brain activity can be triggered primarily by singing. While singing, the brain areas responsible for verbality and pitches, memory, accents, and emotions are activated simultaneously.

According to Schlaug[45], musical training has a positive impact on both verbal and non-verbal skills. Different musical instruments affect different areas of the brain; keyboards or stringed instruments affect the brain differently than singing does.

Making music is one of the most complex human activities, activating a sophisticated network of nerves and muscles. When playing an instrument in a virtuoso fashion, one pushes the limits of his or her ability. Regarding this, Zsuzsa Pásztor[46] cites a study by American neurologist Frank Wilson (2000), according to which "Simon Barere, the famous piano virtuoso, plays 20-30 notes per second when playing Schumann's Op. 7 Toccata in C major. For this, not only the motor centers and pathways, but the entire brain and all three hundred billion neurons in it must function in perfect organization."

Pedagogical advantages of music education

In the following section, I will illustrate the pedagogical advantages of learning music. Early music education, that is, intense exposure to music including the methods of differentiated education begins at least one year before attending school, and helps prepare children to successfully start their public education. It also compensates for family and social disadvantages, and creates the possibility that children entering school might start with almost levels of preparedness, giving them the same initial chances at the start of their studies[47].

---

[44] Fekete, Zsófia. Zeneterápia a neurorehabilitációban (Music therapy in Neurorehabilitation). In: Falus, András ed., *Zene és egészség*. Kossuth Kiadó, Budapest, 2016, pp. 112-127.

[45] Schlaug, Gottfried, Chapter 3—musicians and music making as a model for the study of brain plasticity, in: Altenmüller, Eckart, Finger, Stanley, Boller, Francois, eds., *Progress in brain research: music, neurology, and neuroscience: evolution, the musical brain, medical conditions, and therapies*, vol 217. Elsevier, Amsterdam, 2015, pp 37–55.

[46] Pásztor, Zsuzsa. A zenészek fokális disztóniája, (Musicians' focal distonia). In: *Parlando* 2015/5. available: http://www.parlando.hu/2015/2015-5/PasztorZsuzsa.htm, 2015. (2023. 01. 23.)

[47] Hegedűsné, Tóth, Zsuzsanna. Iskolássá érni énekkel, zenével – egy hatásvizsgálat bemutatása. (Maturing to attend school with singing and music – the introduction of an impact assessment). In: Falus, András Ed., *Zene és egészség*. Kossuth Kiadó, Budapest, 2016, pp. 212-237.

The change in responses elicited by speech sounds is a particularly important result during music learning, because socially disadvantaged children have a higher risk of reading and language problems. Thanks to music, those neural changes are created by adjusting auditory processing, making it possible to distinguish speech sounds more accurately.

In 1966, experiments with developmentally delayed children were already underway in the United States, applying the American adaptation of Kodály's ideas. The results showed that, despite their poor abilities, they were able to achieve much better results in other subjects than they would have otherwise and fared much better than the control group. Similarly, the method was tried for disadvantage compensation in Boston and New Haven, where the method was applied to groups of disadvantaged children of color. "The groups struggling with language difficulties and difficult to civilize showed positive development in all directions in addition to regular, systematic music teaching, the transfer effects of music education were clearly evident"[48].

Based on Schlaug's research[49], music strengthens the basic ability to comprehend ideas and concepts, this effect being clearly observable in the treatment of language deficiencies. In this way, the development of dyslexic children is an area where learning music can play a significant role.

Working memory, an area of deficiency which often occurs in dyslexic people, is improved by music, knowing that when reading sheet music, memory is needed to recognize the melody. When the songs are shown with hand signals, it is necessary to be able to navigate in larger units: it is important to have the notes in correct order and to pay attention to what the next note will be. It is essential that the temporal and spatial characteristics of the movement match the musical parameters, in addition, the articulation and the speed of the movement convey the rhythm and the individual musical units. Also, the quality of the movement determines the music's character. The use of hand signals also harmonizes fine motor skills, large movement, and the movement of sound-producing organs.

It is possible that the immaturity and/or disturbance of sensorimotor coordination might be behind reading difficulties. As musical activity is a multi-sensory stimulus - as we saw earlier - it helps to coordinate systems, and develop memory and attention as well, since stimuli arrive through multiple channels.

---

[48] Szőnyi, Erzsébet. *Kodály Zoltán nevelési eszméi (Educational views of Zoltán Kodály)*. Tankönyvkiadó, Budapest, 1984, p. 36.

[49] Schlaug, Gottfried, Chapter 3—musicians and music making as a model for the study of brain plasticity, in: Altenmüller, Eckart, Finger, Stanley, Boller, Francois, eds., *Progress in brain research: music, neurology, and neuroscience: evolution, the musical brain, medical conditions, and therapies*, vol. 217. Elsevier, Amsterdam, 2015, pp. 37–55.

Dyslexic children are characterized by a general immaturity of the nervous system. They tire easily, they can only concentrate for short periods of time and their memory is worse. This is often accompanied by an undeveloped sense of duty, which causes frequent negative feedback and can lead to serious behavioral problems later. Musical exercises, however, contribute to the development of the nervous system, and experiencing success increases their self-confidence. more self-confidence can help them overcome negative feedback, thus preventing secondary behavioral problems.

Overall

I believe that the transfer effects discussed in this study, as well as the possibility for learning music to have a diverse pedagogical effect, will confirm to the reader that it is worth teaching music to children and for them to learn. It is important to inform parents and make known the social effects of music education, so that children can take advantage of both the joys and the multifaceted developmental benefits music.

REFERENCES

Altenmüller, Eckart, *Musikalsiches Lernen und Hirnentwicklung* Available: http://www.clubofrome.de/schulen/schulen/downloads/altenmueller_musikalisches_lernen_hirnentwicklung.pdf, 2006, (downloaded: 12.08.2014).

Altenmüller, Eckart, Schlaug, Gottfried. Music, brain, and health: Exploring biological foundations of music's health effects. In MacDonald, Rajmond, Kreutz, Gunter & Mitchell, Laura eds., *Music, health and wellbeing*. Oxford University Press, New York, 2012, pp. 11-24.

Anvari, Sima H., Trainor, Laurel J., Woodside, Jennifer, Levy, Betty, Ann, Relations among musical skills, phonological processing, and early reading ability in preschool children. In: *Journal of Experimental Child Psychology,* 83. vol. 2, 2002, pp. 111–130.

Barkóczi, Ilona, Pléh, Csaba. *Kodály zenei nevelési módszerének pszichológiai hatásvizsgálata. (The psychologicalimpact assessment of Kodály's musical education method.).* Kodály Intézet, Kecskemét, 1977.

Clift, Stephen, M., Hancox, Grenville. The perceived benefits of singing: findings from preliminary surveys of a university college choral society. In: *The Journal of The Royal Society for the Promotion of Health***,** 121. vol. 4, 2001, pp. 248-256.

Clift, Stephen, Hancox, Grenville, Morrison, Ian, Hess, Barbel, Kreutz, Gunter, Stewart, Donald. Choral singing and psychological wellbeing: Quantitative and qualitative findings from English choirs in a cross-national survey. in: *Journal of Applied Arts and Health*, 1. vol. 1, 2010, pp.19-34.

Csíkszentmihályi, Mihály. *Flow.* Akadémia Kiadó, Budapest, 2001.

Dingle, Genevieve, A., Brander, Christopher, Ballantyne, Julie, Baker, Felicity. A., 'To be heard': The social and mental health benefits of choir singing for disadvantaged adults, in: *Psychology of Music*. 40. vol. 3, 2012, pp. 1–17.

Fekete, Zsófia, Zeneterápia a neurorehabilitációban. [Music therapy in Neurorehabilitation], in: Falus, András ed., *Zene és egészség*. Kossuth Kiadó, Budapest, 2016, pp. 112-127.

Gévayné, Janurik, Márta, Józsa, Krisztián, Zene és tanulás. [Music and education], in: *Tanító*, 54, vol. 1, 2016, pp. 21-24.

Gick, Mary, L., Singing, health and well-being: A health psychologist's review, in: *Psychomusicology: Music, Mind & Brain,* 21. vol. 1-2, 2011, pp.176-207.

Gombás, Judit, Stachó, László. *Matematikai és zenei képességek vizsgálata 10-14 éves gyerekeknél*. *(Examination of mathematical and musical abilities in children aged 10-14)*. Available: elib.kkf.hu/okt_publ/tek_2006_35.pdf, 2004, (downloaded: 06.22.2015).

Gromko, Joyce. The effect of music instruction on phonemic awareness in beginning readers, in: *Journal of Research in Music Education*, 53. vol. 3, 2005, pp.199–209.

Gyarmathy, Éva. A digitális kor és a sajátos nevelési igényű tehetség. (The digital age and the special education need talent). In: *Fordulópont*, 51, 2011, pp. 79–88.

Hallam, Susan. The power of music: its impact on the intellectual, social and personal development of children and young people. In: *International Journal of Music Education,* 28. vol. 3, 2010, pp. 269–289.

Harmat, László, Tardy, József. *A gyógyító zene*. *(Healing music).* Új Ember Kiadó, Budapest, 2013.

Hámori, József. *Az emberi agy aszimmetriái*. *(The asymmetry of human brain),* Dialóg Campus Kiadó, Budapest-Pécs, 2002.

Hámori, József, Az emberi agy plaszticitása. [The plasticity of human brain], in: *Magyar Tudomány*, 50. vol. 1, 2005, pp. 43-51.

Hebb, Donald, O. *The Organization of Behavior: A Neuropsychological Theory*, John Wiley & Sons, Inc., New York, 1949.

Hegedűsné, Tóth, Zsuzsanna. Iskolássá érni énekkel, zenével – egy hatásvizsgálat bemutatása. [Maturing to attend school with singing and music – the introduction of an impact assessment]. In Falus, András Ed. *Zene és egészség.* Kossuth Kiadó, Budapest, 2016, pp. 212-237.

Ho, Yim-Chi, Cheung, Mei-Chun, Chan, Agnes, S., Music training improves verbal but not visual memory: Cross-sectional and longitudinal explorations in children, in: *Neuropsychology*, 17. vol. 3. pp. 439–450, 2003.

Hüther, Gerald, Digitális média és gyermeki agy, Virtuális világok bűvöletében. [Digital media and children's brain. Under the charm of virtual reality], in: *Élet és Tudomány*, 64. vol. 13. pp. 405-408, 2009.

Hyde, Krista, L., Lerch, Jason, Norton, Andrea, Forgeard, Marie, Winner, Ellen, Evans, Alan, C., Schlaug, Gottfried, The Effects of Musical Training on Structural Brain Development, in: *The Journal of Neuroscience*. 29 vol. 10. pp. 3019–3025, 2009.

Janurik, Márta, A zenei képességek szerepe az olvasás elsajátításában. [The role of musical skills in reading acquistion], in: *Magyar Pedagógia*, 108. vol. 4. pp. 289–317, 2008.

Juhász, Gabriella, Funkcionális mágneses rezonanciás képalkotó vizsgálatok a fájdalom kutatásban. [Functional MRI examinations in pain research], Semmelweis Egyetem, Gyógyszerhatástani Intézet MTA-SE-NAPB Genetikai Agyi Képalkotó Migrén Kutató csoport, 2015.

Kells, Deanne, The Impact of Music on Mathematics Achievement.http://www.kindermusik.com/Classes/Downloads/ ImpactOfMusicOnMath.pdf, 2009.

Kodály, Zoltán, *Visszatekintés [Looking back]*, Zeneműkiadó Vállalat, Budapest, pp. 588-589, 1982.

Kokas, Klára, *Képességfejlesztés zenei neveléssel. [Skill development with music education],* Zeneműkiadó, Budapest, 1972.

Kreutz, Gunter, Bongard, Stephan, Rohrmann, Sonja, Grebe, Dorothee, Bastian, H. Günther, Hodapp, Volker. Does singing provide health benefits? In *Proceedings of the 5th Triennial ESCOM Conference*, 2003, pp. 216-219.

Laczó, Zoltán, „Zenepedagógia és társadalom" [Music pedagogy and society], in: *Hang és lélek*, Magyar Zenei Tanács, Budapest, 2001.

Löwel, Siegrid, Singer, Wolf, Selection of Intrinsic Horizontal Connections in the Visual Cortex by Correlated Neuronal Activity. In: *Science*, 255. vol. 5041, 1992, pp. 209-212.

Milovanov, Riia, Huotilainen, Minna, Valimaki, Vesa, Esquef, Paulo, A. A., Tervaniemi, Mari. Musical aptitude and second language pronunciation skills in school-aged children: Neural and behavioral evidence. In: *Brain Research,* 1194, 2008, pp. 81–89.

Milovanov, Riia, Pietila, Paivi, Tervaniemi, Mari, Esquef, Paulo A. A. Foreign language pronunciation skills and musical aptitude: A study of Finnish adults with higher education. In *Learning and Individual Differences,* 20. vol. 1, 2010, pp. 56–60.

Moreno, Sylvain, Marques, Carlos, Santos, Andreia, Santos, Manuela, Castro, Sao, Luís, Besson, Mireille. Musical training influences linguistic abilities in 8-year-old children: more evidence for brain plasticity. In *Cerebral Cortex,* 19. vol. 3, 2009, pp. 712–723.

Nisbet, Steven. Mathematics and music. In *The Australian Mathematics Teacher*, 47. vol. 4, 1991, pp. 4–8.

Pásztor, Zsuzsa. A zenészek fokális disztóniája, (Musicians' focal dystonia). In: *Parlando* 2015/5. Available: http://www.parlando.hu/2015/2015-5/PasztorZsuzsa.htm, 2015 (downloaded: 2022. 05. 23).

Prensky, Marc. Digital Natives, Digital Immigrants. In *On the Horizon*. MCB University Press, vol. 9, 2001.

Schellenberg, E. Glenn, Long term positive associations between music lessons and IQ, in: *Journal of Educational Psychology*, 98. vol. 2, 2006, pp. 457–468.

Schewe, F. Philip, Music Improves Brain Function. available: https://www.livescience.com/7950-music-improves-brain-function.html, 2009 (downloaded: 05.27.2022).

Schlaug, Gottfried, Chapter 3—musicians and music making as a model for the study of brain plasticity, in: Altenmüller, Eckart, Finger, Stanley, Boller, Francois, eds., *Progress in brain research: music, neurology, and neuroscience: evolution, the musical brain, medical conditions, and therapies*, vol 217. Elsevier, Amsterdam, 2015, pp. 37–55.

Schmithorst, Vincent, J., Holland, Scott, K. The effect of musical training on the neural correlates of math processing: a functional magnetic resonance imaging study in humans. In: *Neuroscience Letters,* 354, 2004, pp. 193–196.

Schumacher, Ralph. *Bessere Noten durch Musik?* available: http://www.lernwelt.at/downloads/machtmozartschlaudrralphschumacher.pdf, 2014, (downloaded: 12. 08.2014).

Slevc, L. Robert, Miyake, Akira. Individual differences in second language proficiency: does musical ability matter? In *Psychological Science*, 17, vol. 8, 2006, pp. 675−681.

Spelke, Elizabeth. Effects of Music Instruction on Developing Cognitive Systems at the Foundations of Mathematics and Science, in: Asbury, Carolyn, Rich, Barbara eds., *Learning, Arts, and the Brain*. Dana Press, New York, 2008, pp. 17–49.

Szőnyi, Erzsébet. *Kodály Zoltán nevelési eszméi* (*Educational views of Zoltán Kodály),* Tankönyvkiadó, Budapest, 1984.

Szűcs, Tímea. *Alapfokú művészeti iskola, egy esélynövelő iskolatípus (Primary art school, a school type that increases students' chances),* Debreceni Egyetemi Kiadó, Debrecen, 2019.

Tallal, Paula, Gaab, Nadine. Dynamic auditory processing, musical experience and language development. In *Trends in Neuroscience,* 29, vol. 7, 2006, pp. 382−390.

Thompson, William, Forde, Schellenberg, E. Glenn, Ilie, Gabriela. Decoding speech prosody: Do music lessons help? In *Emotion,* 4. vol. 1, 2004, pp. 46–64.

Vandulek, Csaba. *A modern funkcionális keresztmetszeti képalkotás integrálása központi idegrendszeri tumorok 3D alapú sugárkezelési eljárásaiba. (The integration of modern functional crossection imaging into 3D-based radiation treatment procedures of tumors in the central nervous system.* PhD dissertation, Pécs, 2016.

Wan, Catherine,Y. and Schlaug, Gottfried. Music making as a tool for promoting brain plasticity across the life span. In *Neuroscientist,* 16, 2010, pp. 566–577.

Wenger, Win, Wenger, Susan, Honey, Training music sight-reading and perfect pitch in young children, as a way to enhance their intelligence, in: *Journal of the Society for Accelerative Learning and Teaching*, 15. vol. 77–89, 1990.

Wong, Patrick, C. M., Perrachione, Tyler, Learning pitch patterns in lexical identification by native English-speaking adults, in: *Applied Psycholinguistics,* 28. vol. 4, 2007, pp. 565–585.

Wong, Patrick, C. M., Skoe, Erika, Russo, Nicole, M., Dees, Tasha, Kraus, Nina. Musical experience shapes human brainstem encoding of linguistic pitch patterns, in: *Nature Neuroscience,* 10. vol. 4, 2007, pp. 420–422.

Young, Laurel. The potential health benefits of community-based singing groups for adults with cancer. In *Canadian Journal of Music Therapy*, 15. vol. 1, 2009, pp. 11-27.

Zatorre, Robert, J., Chen, Joyce, L., Penhune, Virginia, B. When the brain plays music: auditory-motor interactions in music perception and production. In *Nature Reviews Neuroscience*, 8. vol. 7, 2007, pp. 547-558.