MOZART'S MUSIC – A UNIVERSAL LANGUAGE FOR THE HUMAN BRAIN

The aim of this research paper is to present different perspectives on why Mozart's music speaks so universally to the human brain. It seems that Mozart's music, when compared to other types of music, carries in itself a special code so that every human brain understands it equally and that the reaction to it is universal. The results of different research studies give us many different answers about the cause of this unique effect; one of the main explanations lies in the frequency structure of Mozart's music, and another in the symmetrical structure of Mozart's compositions.

First, we establish the idea of music as the first language of humankind from a phylogenetic and ontogenetic point of view on the basis of many research studies. Second, the connection between music and language from different perspective is introduced.

The focus of the paper is on the Mozart effect (ME) – the influence of Mozart's Sonata for Two Pianos in D major, K448, on spatial-temporal reasoning. We present the main outcomes of our research studies that we conducted on Slovene students; first the three preliminary neurological studies were performed, followed by the main experiment on the sample of 315 students. A summary of our main conclusions from neurological studies is that there is a universal and specific effect of Mozart's music on the human brain. The universal effect could be recognized in the "binding" of different brain areas when listening to the music, so that the brain works more synchronically and holistically. On the other hand, the specific effect is seen in enhanced mental concentration, which results in better reasoning. The results of our central experiment showed that the group with ME and the group without ME differed in general intelligence and in learning styles; subjects who had experienced ME processed information more on auditory and holistic level and showed lower IQ compared to the group without ME. We proposed the idea that Mozart's music can be used as a tool of cognitive optimization in some individuals.

Keywords: Mozart's music, universal language, Mozart effect, human brain, cognitive optimization

INTRODUCTION

As Plato said, *"Music gives a soul to the universe, wings to the mind, flight to the imagination and life to everything."* If we were truly aware of all the benefits that music holds in itself, we would implement it in every human activity.

Hindus were convinced that the universe was born out of music; the ancient Chinese and Egyptians believed that music reflects the main principles in the universe, and the ancient Greeks thought that music has a healing power and is also the most important element of a good education.

Music is an essential component of human functioning that provides adaptive value. Music is supposed to be genetically written into the human genome, and represents the most ancient language of humankind. Musical activities, such as listening and creating, are among the evolutionarily oldest abilities of humankind. From the phylogenetic point of view, music can be interpreted as the first means of communication for humankind. It was primarily oriented towards expressing an individual's emotional state. It is supposed that music was used as a means of communication in mate selection, social cohesion, group effort, conflict reduction, and trans-generational communication (Huron, 2003). On the other hand, the ontogenetic development of the human species also supports the idea of the importance of sound and music. The ear is the first organ to develop in the embryo and becomes functional after only eighteen weeks; it listens actively from twenty-four weeks onwards. There is clear evidence of an in utero response to music (Leader et al. 1982; Lecanuet, Granier-Deferre, & Busnel, 1988).

Music – the first language of humankind

The use of music as a means of communication is evident from different theories about the evolutionary origins of music. According to Wilfried Gruhn (2006) musical abilities played a key role in the evolution of language in the phylogeny of man. Rousseau (1781/1993) (see Ackermann et al., 2006) was convinced that the first languages were sung, not spoken. According to him, language evolved from music for the sake of expressing emotions and a rational organization of human societies. As part of his evolutionary theory, Charles Darwin (1871) interpreted proto-musical emotional expressions as a step towards language; whereas

Herbert Spencer (1857) made the opposite assumption that it is only the emotional content of language that has led to music (see Ackermann, Wildgruber, & Riecker, 2006).

Neurobiology can offer new explanations that are in contrast with the old debate on the origins of music and language (Wallin, Merker, & Brown, 2000).

Roedere (1984) concluded that music has several advantages over language. Singing is much louder than speaking, so singing may facilitate group interactions.

The connection between language and music

Language and music are genuine human universals that are present in every culture. The interest in the music–language relationship is over 2,000 years old, going back to Plato. The question of a common or separate origin of language and music was at the center of hot debates between philosophers and scientists from the seventeenth to the nineteenth centuries (Besson & Schoen, 2003). The first basic function of both language and music was probably to express emotive meaning through variations in the intonation of the voice (intonational prosody) and rhythm (Brown, 2000; Molino, 2000; Spencer, 1857).

In the last decade, the common roots of music and language have been confirmed in an evolutionary and neurobiological sense, which has led to the idea of a “musilanguage” (Brown, 2000) and initiated new lines of research on animal and human vocal communication. There is an increasing interest in the emotional prosody of animals (bats, monkeys, mice, and rats) as in the cries of infants (Lehr et al., 2007; Zeskind, 2007) and infants’ early pre-verbal vocalizations (Leimbrink, 2010). From an early child development perspective, many scholars believe that music and language are equally important and share some commonalities during infancy (see Ilari, 2002; Trehub, 2002; Trevarthen & Malloch, 2002). Parental speech to infants has many music-like characteristics. Some researchers have even argued that the melody is the message that is transmitted to pre-verbal infants (Fernald, Taeschener, Papousek, Boysson-Bardies, & Fukui, 1989). According to these scholars, babies are attuned and respond to the melodic contours found in parental speech and in infant-directed singing (Trehub, 2003).

One of the most prominent researchers addressing the connection between music and language is Anruddh D. Patel, who wrote a book called *Music, Language and the Brain* in

2008. Patel (2008) claims that music and language share many similarities, but also some differences. He recognizes similarities in rhythm (systematic patterns of timing, accent, and grouping), melody (structured patterns of pitch overtune), syntax (discrete elements and principles of combination) and affect (you can read emotions in the sound of a person's voice or in a piece of music). On the other hand, he emphasizes the differences in rhythm (language does not have a beat), melody (melodies use stable pitch intervals), syntax (from music you cannot tell who did what to whom and why) and affect (which is sometimes difficult to recognize exactly in music). Patel proposed the idea that there are also hidden connections between music and language; one of his research conclusions was that instrumental music reflects composers' native language, and that speech patterns enter the music through implicit learning (the rhythm of the language of early childhood). Regarding syntax he proposed a theory about resource sharing, which claims that there are common neuro resources (integrative processes) for organizing language and music. He is convinced that musical harmonic processing interferes with linguistic syntactic processing but does not interfere with semantic processing (so patients with aphasia also have problems with musical syntax).

Perrachione1, Fedorenko,Vinke, Gibson & Dilley (2013) had investigated how pitch processing is shared between language and music by measuring consistency in individual differences in pitch perception across language, music, and three control conditions intended to assess basic sensory and domain-general cognitive processes. Their results showed that individuals' pitch perception abilities in language and music are most strongly related, which is consistent with presumption that cognitive mechanisms for pitch processing may be shared between language and music.

Morril and colleagues (2015) examined the relationship between music and speech prosody processing, while controlling for cognitive ability. Their results revealed that only music perception was a significant predictor of prosody test performance. Music perception accounted for 34.5% of variance on prosody test performance; cognitive abilities and music training added only about 8%. The authors concluded that musical pitch and temporal processing are highly predictive of pitch discrimination in speech processing.

Music, language and the brain

Several studies have investigated the similarities and differences between language and music in brain functioning. Despite the view of some linguists that music and language are strictly separate domains (Pinker, 1997), the combined findings indicate that the human brain engages a variety of neural mechanisms for the processing of both music and language, underscoring the intimate relationship between music and language in the human brain.

Besson & Schön (2001) conducted a comprehensive meta-analytical review of brain imaging studies trying to examine similarities and differences between language and music processing from an evolutionary and a cognitive perspective. They concluded that results favor language specificity when certain aspects of semantic processing in language are compared with certain aspects of melodic and harmonic processing in music. On the other hand, when aspects of syntactic processing in language are compared with aspects of harmonic processing in music, results support the view that general cognitive principles are involved.

Let us start first with the differences between language – music processing since they are fewer.

According to Jackendoff (2008): »Language and music differ substantially in their rhythmic structure, in their use of pitch, in their "meaning" (propositional versus affective), and in the form and function of their hierarchical structures.«

Considering differences in the rhythmic structure an interesting interdisciplinary study was conducted by Magne et all. (2004). The Event-Related Brain Potential method was used to study perceptual and cognitive processing related to the rhythmic and semantic/harmonic incongruities. »The results indicated that the processing of rhythmic incongruities was associated with increased positive deflections in the Brain Potential in similar latency bands in both language and music. However, these positivities were present independently of the participants' focus in the music part while they were only present when the participants focused on semantics in the language part.«

Considering the difference in lateralization language processing is a function more of the left side of the brain than the right side, and takes place particularly in Broca's area and Wernicke's area. On the other hand music is processed by both the left and the right sides of the brain (Koelsch, Gunter, Friederici, & Schröger, 2000).

Stewart, Walsh, Frith and Rothwell (2006) studied the differences between speech production and song production using transcranial magnetic stimulation (TMS). Stewart et al. (2006)

found that TMS applied to the left frontal lobe disturbs speech but not melody, supporting the idea that speech and melody are subserved by different areas of the brain. The authors suggest that a reason for this difference is that speech generation can be localized well, but the underlying mechanisms of melodic production cannot. Alternatively, they suggested that speech production may be less robust than melodic production and thus more susceptible to interference.

Differences in brain functioning for processing music and language were also confirmed with ERP studies. It was concluded that the processes that govern semantic expectancy and are reflected by a negative component, peaking at around 400 ms, the N400, are qualitatively different from those involved in musical expectancy that are reflected by a positive peaking at around 600 ms, P600 (Besson & Schoen, 2003).

On the other hand there are several contemporary studies supporting the parallels between language and music processing.

It has been shown that certain aspects of language and melody are processed in near identical functional brain areas. Brown, Martinez and Parsons (2006) examined the neurological structural similarities between music and language using positron emission tomography (PET). Their study showed that linguistic and melodic phrases produce activation in almost identical functional brain areas, such as the primary motor cortex, the supplementary motor area, Broca's area, the anterior insula, the primary and secondary auditory cortices, the temporal pole, the basal ganglia, the ventral thalamus and the posterior cerebellum. The majority of activations were bilateral, differences were found only in lateralization tendencies, as language tasks favored the left hemisphere.

Kunert and colleagues (2015) used fMRI to examine anatomical overlap of brain activity involved in linguistic and musical syntactic processing. Their results showed that the processing demands of musical syntax (harmony) and language syntax interact in Broca's area. A language main effect in Broca's area only emerged in the complex music harmony condition, suggesting that (with our stimuli and tasks) a language effect only becomes visible under conditions of increased demands on shared neural resources. The authors had concluded that two different cognitive domains—music and language—might draw on the same high level syntactic integration resources in Broca's area. Furthermore Musso and colleagues (2015) examined the brain network involved in the recognition and integration of words and chords that were not hierarchically related to the preceding syntax. They used functional magnetic resonance imaging with functional connectivity and diffusion tensor imaging-based probabilistic tractography. Their study is supposed to be the first to compare in the same subjects the specific spatial distribution and the functional and anatomical connectivity of the neuronal resources that activate and integrate syntactic representations during music and languageprocessing. Their data indicated that a dual-stream system with dorsal and ventral long association tracts centered on a functionally and structurally highly differentiated left inferior frontal gyrus is pivotal for domain–general syntactic competence over a broad range of elements including words and chords

The second important similarity between language and music has been shown in brain processing of the syntactical information mechanisms in both music and language. Jentschke, Koelsch, Sallat and Friederici (2008) conducted a study investigating the processing of music in children with specific language impairment (SLI) using two specific event-related brain potential (ERP) components to investigate music-syntactic processing in children: the ERAN (early right anterior negativity) and the N5. The results showed that neither an ERAN nor an N5 was elicited in children with SLI, whereas both components were evoked in age-matched control children with typical language development. Moreover, the amplitudes of ERAN and N5 were correlated with subtests of a language development test. In their later study Jentschke & Koelsch (2009) compared the neural correlates of language- and music-syntactic processing between children with and without long-term musical training. Their data suggest that the neurophysiological mechanisms underlying syntax processing in music and language are developed earlier, and more strongly, in children with musical training. More precisely, musically trained children had larger amplitudes of the ERAN (early right anterior negativity), elicited by music-syntactic irregularities, and the ELAN (early left anterior negativity), a neurophysiological marker of syntax processing in language.

Shared processing between language and music has also been confirmed at the conceptual level. According to Deutsch and her colleagues (Deutsch, Henthorn, Marvin, & Xu, 2006; Deutsch, Dooley, Henthorn, & Head, 2009) the prevalence of absolute pitch is much higher for speakers of tone languages, even controlling for ethnic background, showing that language influences how musical tones are perceived

Interesting research studies comparing similarities and differences between language an music were performed also on poetry. Studies comparing poetry to music reveal that more emotionally charged writing arouses several of the regions in the brain that respond to music.

These areas, predominantly on the right side of the brain, had previously been shown to give rise to the "shivers down the spine" caused by an emotional reaction to music" (Zeman, Milton, Smith, & Rylance, 2013). It can be concluded that grouping, meter, duration, contour, and timbral similarity are mind/brain systems shared by music and language, whereas linguistic syntax and semantics, and musical pitch relations, are systems not shared by the two domains (Lerdahl, 2001). "

If we sum up, the results of the brain studies confirm, that on the one hand there is language in music, and on the other, that there is also music in language. The brain processing in language and music is bilateral, but there are many brain systems not shared by the two domains.

What is the Mozart effect?

The Mozart effect refers to an enhancement of performance in spatial-temporal reasoning or a change in neurophysiological activity associated with listening to Mozart's Sonata for Two Pianos in D major. The effect was first reported in 1993 by Rauscher, Shaw and Ky.

There have been several studies confirming the Mozart effect (Habe, 2005; Jaušovec & Habe, 2003, 2005; Lin et al., 2010; Lin et al., 2014; Rideout, Dougherty & Wernert, 1998; Rideout & Laubach, 1996; Rideout & Taylor, 1997; Turner, 2004; Wilson & Brown, 1997). However, many studies have failed to replicate it (Carstens, Huskins & Hounshell, 1996; Črnčec, Wilson & Prior, 2006; McCutchen, 2000; McKelvie & Low, 2002; Newman, Rosenbach, Burns, Latimer, Matocha, & Vogt, 1995; Steele, Ball & Runk, 1997; Steele, Bass & Crook, 1999; Steele, Brown & Stoecker, 1999; Pietschnig,Voracek & Formann, 2010).

Studies on the Mozart effect can be organized into three main categories: (1) Mozart effect listening experiments; (2) direct tests of the trion model of higher brain function; and (3) music training that enhances children's spatial-temporal reasoning and math learning. In general, we can say that studies into the Mozart effect involve using Mozart's music as a window into higher brain function. The starting point for all the research is that the human brain possesses a built-in, innate ability to recognize symmetries and to use them to see how patterns develop in space and time. The trion model of the cortex provides a causal basis for relationships between musical ability and spatial reasoning ability. The main purpose of the research into the Mozart effect is to gain a better understanding of higher brain functions; music is just being used as a mediator, as a key to understanding how we think, reason, and create, and how we can enhance these higher brain functions through our innate spatial-temporal reasoning abilities. Mozarts' music was used as "the most optimal window" among different musical genres and composers for studying higher brain functions.

Clémentine Beauvais (2015) adressed Mozart effect (ME) as an interesting sociocultural phenomenon in the late 20th century in America. She claimed that » Phenomena like the 'Mozart Effect' do not just take advantage of a fortuitous alignment of circumstances, but lastingly modify in turn the different fields which have allowed them to grow.« By her oppinion the popular and commercial success of the ME rested on the belief, cultivated by advertising, that certain possessions can confer positive attributes to those who come into close contact with them.

Neurological basis of the Mozart effect

Although brain functions are typically associated with specific, localized regions of the cortex, higher cognitive abilities draw upon a wide range of cortical areas (Petsche, Richter, von Stein, Etlinger, & Filz, 1993; Sarnthein et al., 1997). Leng and Shaw (1991) proposed that exposure to music excites the cortical firing patterns used in spatial-temporal reasoning, thereby affecting cognitive ability in tasks that share the same neural code as spatial-temporal tasks.

The improvement of spatial reasoning capabilities after listening to music has been studied by electroencephalographic (EEG) power analysis (Rideout & Laubach, 1996). Sarnthein et al. (1997) reported the presence of right frontal and left temporo-parietal coherent activity which was induced by listening to Mozart and which carried over into spatial-temporal tasks in three of seven subjects. This carry-over effect was compared to the results of an EEG coherence analysis of spatial-temporal tasks after listening to text. The authors suggest that these EEG coherence results provide the beginnings of an understanding of the neurophysiological basis of the causal enhancement of spatial-temporal reasoning after listening to specific music. The observed long-lasting coherent EEG pattern might be evidence for structured sequences in cortical dynamics that extend over minutes.

Bodner, Mutfuler, Nalcioglu, and Shaw (2001) used fMRI to examine the specific structural activations that occur in subjects during exposure to the Mozart Sonata (K448) but not during exposure to control (piano) music. They found, in particular, that listening to the Mozart Sonata (K448) resulted in the activation of the prefrontal and auditory cortex for all three subjects. The fact that no prefrontal activation was observed for either the popular or the Beethoven piano music (which was familiar to the subjects) shows that this activation was not due to expectations from knowing the piece, general expectations because the piece was classical, or some type of general build-up or discharge of activity.

Why does Mozart's music speak so universally to the human brain?

Musicologist Ulrich Konrad (2008) wandered as many others have: "What makes Mozart's music so exceptional? What makes it different from other works of his epoch, the classical period, with its clear rules for the form and harmony of compositions?" According to him, "Mozart found astonishing combinations within the usual, and used these in such a fitting way that it sounds unique for his time, and often exceptional. Mozart described his ideal simply like this: *"The middle-thing – the truth in all things."* So we could conclude that imperative of classicism of finding harmony and balance in arts, in Mozart's music was perfectly accomplished.

There are a few different explanations of why Mozart's music speaks so universally to our brains: (1) the high frequency structure in his music (Campbell, 2001); (2) the balance between tension and relaxation in his music (Balzer, 2009); (3) the inherent symmetry of his music (especially piano sonatas) that overlaps with spatial-temporal reasoning in our brain (Shaw, 2000); and (4) the Golden Ratio/Golden Section in his musical compositions (Putz, 1995).

Don Campbell (2001) claimed that much of Mozart's music is in the high frequency range, which Alfred Tomatis (1991) found to contain the most stimulating and emotionally charged aspects of sound. The higher frequencies help activate our brains and increase attentiveness.

In the year 2000, Hughes and Fino conducted research to address the question of why Mozart's music so specifically results in a decrease of epileptiform activity. Their conclusion was that one distinctive aspect of Mozart's music is its long-term periodicity, which may well resonate within the cerebral cortex and may also be related to coding within the brain.

Prof. Dr. Hans-Ulrich Balzer (2009), a researcher at the Salzburg University Mozarteum, proved by chrono-biological analysis that listening to Mozart's music leads to an astonishingly quick synchronization with the body's own rhythms, as the steering of the rhythms happens through processes taking place in the brain. Balzer's observations are in line with the discovery of Wolf Singer (2005), the famous German brain researcher that the brain operates like an orchestra.

"One of the most controversial theories about the Mozart effect is Putz's theory (1995) about the Golden Ratio/Golden Section in Mozart's music. Putz measured those of Mozart's piano sonatas that were most convenient because they are customarily divided into two parts: (1) the exposition; and (2) the development and recapitulation. Many Mozart piano sonatas seem to employ the Golden Section, but there are also some that deviate considerably. Putz therefore could not conclude that Mozart consciously used the Golden Section to "improve" his music, but he definitely used it frequently."(Science Frontiers.com)

The mathematical astrophysicist Mario Livio (2003, 2005) has studied the relationship between art and mathematics. He is convinced that most people are attracted to symmetry when there are also some elements of surprise. In these elements of surprise he sees the answer to why Mozart's music has such a broad and varied effect on human brain functioning.

Shaw (2000), who first pointed out the Mozart effect, proposed a trion theory that is based on a symmetrical concept as a theoretical background for Mozart effect studies. Rauscher and Shaw (1998) argued that music like the Mozart Sonata that is structured in a complex way in tempo, melody, organization, and predictability may also enhance spatial task performance. The link is subserved by similarities in neural activation between music listening and spatial reasoning, as specified in the trion model of cortical organization (Leng & Shaw, 1991; McGrann, Shaw, Shenoy, Leng, & Mathews, 1994; Shaw, Silverman, & Pearson, 1985; Shenoy, Kaufman, McGrann, & Shaw, 1993). Music acts as an exercise that excites and primes the common repertoire and sequential flow of the cortical firing patterns responsible for higher brain functions. The cortical symmetry operations among the inherent patterns are enhanced and facilitated by music (Rauscher, Shaw, & Ky, 1995). Leng and Shaw (1991) proposed that music is a “prelanguage” available at an early age, and can access these inherent firing patterns and enhance the ability of the cortex to accomplish pattern development, thus improving other higher brain functions.

If we sum up all the explanations of the origins of the Mozart effect, we can conclude that Mozart’s music holds a perfect balance between tension and relaxation, which affects the human brain. This perfect balance can also be observed in the symmetrical structure of his music that overlaps with symmetries in higher brain functioning. So Mozart’s music actually primes our brain for better spatial-temporal reasoning. The other explanation lies in its high frequencies, which are very beneficial for human brain functioning.

The main findings from our research work on the Mozart effect (ME)

The aim of our research project on the ME was multifaceted; first we wanted to establish neurological bases of the Mozart effect, the second step was to test the two different previous theories about the origins of ME; indirect (arousal/mood theory) and direct (priming theory); the third important step was to compare the group who experienced ME with the stagnation group, where ME was not evident, in intellectual, personal, emotional characteristics and the differences in learning styles.

The aim of our first study of the Mozart effect (Jaušovec & Habe, 2003) was to test the two different theories about the origins of ME; arousal-mood theory and the priming theory. The sample included 18 individual. We conducted event related responses EEG analysis that employed the methods of induced event-related desynchronization/synchronization (ERD/ERS) and event-related coherence (ERCoh). We used three different musical clips that differed in the level of their complex structure, induced mood, musical tempo and prominent frequency (Mozart’s Sonata (K448), Brahms’ Hungarian Dance No. 5, and a simplified version of the theme from Haydn’s Symphony No. 94 played by a computer synthesizer). Our results showed that Mozart’s music mainly influences the respondent’s level of attention – the level of alertness and expectancy. Our findings speak more in favor of the priming theory, since only the Mozart clip comparing to the other two selected musical clips, with no regard to the level of induced mood, musical tempo and complexity, influenced the level of arousal.

In our second study, we investigated the influence of auditory background stimulation (Mozart's Sonata K448) on visual brain activity (Jaušovec & Habe, 2004). Twenty individuals solved a visual oddball task in two response conditions: while listening to Mozart's Sonata K448, and while listening to nothing. The recorded event-related potentials (ERP) were analyzed in the time and frequency domains. In the theta, lower-1 alpha and gamma band, we observed increases in induced event-related coherences while respondents solved the oddball task and listened to music, whereas we observed a decoupling of brain areas in the gamma band in the silence response condition. Our results confirmed the assumption that auditory background stimulation can influence visual brain activity, even if the two stimuli are unrelated.

In our third study, we investigated the influence of Mozart's Sonata K448 on brain activity during the performance of spatial rotation and numerical tasks (Jaušovec & Habe, 2005). The method of induced ERD/ERS and ERCoh was used. The music condition had a beneficial influence on respondents' performance of spatial rotation tasks, and a slightly negative influence on the performance of numerical tasks when compared with the silence condition. On the psychophysiological level, a general effect of Mozart's music on brain activity in the induced gamma band was observed, accompanied by a more specific effect in the induced lower-2 alpha band that was only present while respondents solved the numerical tasks. It is suggested that listening to Mozart's music increases the activity of specific brain areas, and in that way facilitates the selection and "binding" together of pertinent aspects of sensory stimulus into a perceived whole.

On the basis of the findings of our three neurological studies we can conclude that Mozart's Sonata for Two Pianos in D major speaks universally and specifically to the human brain. The universal effect could be recognized in the "binding" of different brain areas when listening to the music, so that the brain works more synchronically and holistically. On the other hand, the specific effect is seen in the enhanced mental concentration that results in better reasoning.

Our central research study about ME (Habe, 2005) was oriented on the research question as follows: Is the Mozart effect (ME) – i.e. the increase in spatio-temporal reasoning (STR) performance immediately after exposure to a Mozart piano sonata for two pianos K.448 (MS) – a genuinely a universal human phenomenon, or does it differ between individuals with different intellectual abilities, emotional intelligence, personality traits and learning styles.

The experiment was performed on a sample of 315 students, aged 19 to 23. The ME was confirmed by the initial research. Based on the results of the initial experiment, we designed an enhancement group (+ME = 30) and a stagnation group (ØMU=30). Using these two groups, we examined the differences in general intelligence (Advanced Progressive Matrices by Raven, Raven & Court,1999), emotional intelligence (Mayer-Salovey-Caruso emotional intelligence test by Mayer, Salovey & Caruso, 2002)), learning styles (Learning style profile by Keefe & Monk, 1990), and personality (Big Five Observatory by Caprara, Barbaranelli, Borgogni, Bucik, & Boben, 2002). The results indicated that ME is not influenced by the personality and emotional intelligence of an individual. On the other hand, these two groups differed significantly in general intelligence and learning styles; The ME was more pronounced in (1) individuals with lower IQ compared to those with higher IQ, (2) in those who processed information more on auditory and on holistic level (while the stagnation group was more visual and analytical).

Our central study had confirmed that Mozart's sonata for two pianos (K.448) has a positive influence on cognitive functioning, but the extent of its effect depends on the intellectual capacities, the perceptual style and on the method of informational processing of each individual.

Conclusion

We are convinced that music is an essential language of humankind. The evidence for this can be seen from both the phylogenetic and the ontogenetic perspective of human development. In particular, Mozart's music has broad and varied beneficial effects on human brain functioning. Mozart's music definitely speaks universally to the human brain, although the answer to why it does so still remains an unsolved mystery. The real reason for the mysterious effect of Mozart's music probably lies in between different research answers; probably it goes for the combination of at least two factors – the benefit of higher frequency structure on one hand, and the benefit of optimal balance and symmetry in Mozart's' work on the other. Even though the results of different studies about ME are still contradictory and intriguing, the majority of studies confirm the existence of ME on neurophysiological level. Moreover the implications of ME in clinical and educational domain are priceless, so the practitioners just have to be aware of and take into account all the important prerequisites for

ME considering personality (general intelligence, learning style, personality traits, musical background) and situational factors (the use of Mozart's sonata for two pianos K.448 instead of other musical pieces, listening through earphones, listening to music before and not during solving problems, solving spatio-temporal tasks).

Our proposal is that ME can be used as an important tool for cognitive optimization in some individuals.

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