Consciousness and Cognition 35 (2015) 150–155

Contents lists available at ScienceDirect

Consciousness and Cognition

journal homepage: www.elsevier.com/locate/concog

The Mozart Effect: A quantitative EEG study

Walter Verrusio [a,*], Evaristo Ettorre [a], Edoardo Vicenzini [b], Nicola Vanacore [c], Mauro Cacciafesta [a], Oriano Mecarelli [b]

[a] Department of Cardiovascular, Respiratory, Nephrologic, Anesthesiologic and Geriatric Sciences, Sapienza University of Rome, viale del Policlinico 155, Rome, Italy
[b] Department of Neurology and Psychiatry, Sapienza University of Rome, Italy
[c] National Centre of Epidemiology, National Institute of Health, via Giano della Bella 34, Rome, Italy

ARTICLE INFO

Article history:
Received 18 February 2015

Keywords:
Mozart Effect
Problem solving
qEEG
Cognition

ABSTRACT

The aim of this study is to investigate the influence of Mozart's music on brain activity through spectral analysis of the EEG in young healthy adults (Adults), in healthy elderly (Elderly) and in elderly with Mild Cognitive Impairment (MCI). EEG recording was performed at basal rest conditions and after listening to Mozart's K448 or "Fur Elise" Beethoven's sonatas. After listening to Mozart, an increase of alpha band and median frequency index of background alpha rhythm activity (a pattern of brain wave activity linked to memory, cognition and open mind to problem solving) was observed both in Adults and in Elderly. No changes were observed in MCI. After listening to Beethoven, no changes in EEG activity were detected. This results may be representative of the fact that said Mozart's music is able to "activate" neuronal cortical circuits related to attentive and cognitive functions.

1. Introduction

There is a vast amount of scientific evidence to demonstrate how listening to music can have a positive effect on a large number of medical conditions. For example, exposure to some musical stimuli can affect epileptiform activity in patients with seizures (Jenkins, 2001), have beneficial effects in a variety of negative, stress-induced conditions such as anxiety and depression (Attanasio, Cartocci, Covelli, et al., 2012; Bradt, Dileo, Grocke, & Magill, 2011; Verrusio, Andreozzi, Marigliano, et al., 2014), and reduce language impairments, attention deficits and the behavioral and psychological symptoms of dementia (BPSD) (Raglio, Bellelli, Traficante, et al., 2008). It has also been shown how music can affect the learning process and improve the performance of a series of cognitive tasks (Caldwell & Riby, 2007; Jausovec, Jausovec, & Gerlic, 2006; Rauscher, Shaw, & Ky, 1993). Some studies have highlighted the leading role of specific pieces of music such as those by W.A. Mozart and J.S. Bach. The Mozart Effect (ME), an enhancement of performance or change in neurophysiological activity associated with listening to Mozart's music, was described for the first time by Rauscher et al. (1993). Other studies were performed subsequently to check whether or not the Mozart Effect exists. Hetland (2000) reached the conclusion that the ME does exist, but that it is limited to specific types of spatial tasks; it is not limited to Mozart's music, but not all types of music generate said effect. In a recent study, the ME was tested with a set of tests that investigates different cognitive abilities in elderly patients with Mild Cognitive Impairment (MCI): the results obtained showed that listening to Mozart's music can

* Corresponding author at: Department of Cardiovascular, Respiratory, Nephrologic, Anesthesiologic and Geriatric Sciences, Sapienza University of Rome, viale del Policlinico 155, 00161 Rome, Italy.
E-mail address: walter.verrusio@uniroma1.it (W. Verrusio).

http://dx.doi.org/10.1016/j.concog.2015.05.005
1053-8100/

have a positive and reproducible effect on spatial–temporal abilities and on immediate recall involved in short and long-term memory processes (Paper Folding & Cutting test and ''Rey's 15 words test''), opening new frontiers of cognitive rehabilitation for these patients (Cacciafesta, Ettorre, Amici, et al., 2010). However, other studies did not succeed in repeating the ME and some authors have questioned the existence of said phenomenon. Indeed, it is felt that listening to music can affect the performance of cognitive tasks by modifying arousal (the degree of physiological activation) and the mood of the listener (Husain, Thompson, & Schellenberg, 2002; Thompson, Schellenberg, & Husain, 2001). Hence the ME is an artifact of arousal and mood.

Therefore, it is necessary to look for a possible explanation for the positive influence of Mozart's music on the specific cognitive functions. The link between listening to Mozart and spatial–temporal reasoning is subserved by similarities in neural activation, as specified by the Trion model of cortical organization (Shaw, Silverman, & Pearson, 1985). Music acts as an exercise for exciting and priming the common repertoire and sequential flow of the cortical firing patterns responsible for higher brain functions (Rauscher, Shaw, & Ky, 1995). Hughes and Find (2000) highlighted the precise architecture of some musical compositions whose extremely specific physical–mathematical characteristics and rhythmical connotations are able to produce physiological stimulation of the cognitive functions and neuroplastic mechanisms forming the basis of physiological neuronal trophism. One of the distinctive features of Mozart's music is the frequent repetition of the melodic line; this determines the virtual lack of ''surprise'' elements that may distract the listener's attention from rational listening, where each element of harmonic (and melodic) tension finds a resolution that confirms listeners' expectations. The authors advanced the theory that said periodicities are in keeping with a general theme that is a characteristic of Mozart's music, which is highly organized, presumably echoing the organization of the cerebral cortex. It was demonstrated that there is an improvement in cognitive abilities immediately after listening to the K448 sonata and other compositions with the same index of periodicity.

Scientific evidence demonstrated how interaction between music and the brain can cause changes with regard to the brain's electrical activity (Rideout & Laubach, 1996). Rausher and his assistants (1995) proposed an electroencephalographic study. The results showed that K488 increased spatial–temporal reasoning ability through more efficient organization of the right cerebral hemisphere. In another study, listening to music generated a significant increase in the electroencephalogram (EEG) of the beta spectrum (Nakamura, Sadato, Oohashi, et al., 1999). The formulated theory is that listening to music may trigger firing of the rear part of the precuneus which may, in turn, benefit performance of a spatial task. Jausovec and Habe (2003) showed how Mozart's music affects the level of excitement in the cerebral areas linked to attentive processes and spatial–temporal tasks. A study (Bodner, Muftuler, Nalcioglu, & Shaw, 2001) based on functional magnetic resonance imaging (fMRI) highlighted how listening to K448 generated activation also with regard to the dorsolateral prefrontal cortex, occipital cortex and cerebellum, all of which are involved in spatial–temporal functions. These findings suggest that music by Mozart was connected to better performance of spatial- temporal tasks as a result of activation of specific areas of the brain and inhibition of other non-significant areas and that EEG power spectrum may be an indicator of music' s effect.

Therefore, given the close positive association between listening to the Mozart music and ability in spatial–temporal tasks, the aim of this study is to further investigate the influence of Mozart's music on brain activity through spectral analysis of the EEG. On the basis of age-related modifications of EEG patterns, three groups of patients were enrolled in this study: (i) young adults, point of reference in the great majority of studies concerning performance ability in spatial–temporal tasks under the influence of Mozart music; (ii) elderly patients with MCI, since Mozart effect on patients with mild cognitive impairment was reported in a former study (Cacciafesta et al., 2010); (iii) elderly individuals with unknown cognitive deficit. Indeed, it is well-known that aging is marked by a gradual slowing down of dominant background alpha rhythm, accompanied by an increase in the slower theta and delta rhythms (Klass & Brenner, 1995; Sloan & Fenton, 1993). These changes may be more precocious and evident in individuals with MCI, and even more so in individuals with dementia, compared to healthy elderly individuals (Soininen, Partanen, Laulumaa, et al., 1991).

2. Materials and methods

Three groups of individuals were enrolled to perform this study: the first group (Adults) comprised 10 young, healthy individuals (average age of 33 ± 4.55; 5 females); the second group (Elderly) comprised 10 elderly individuals (average age of 85.2 ± 6.12; 7 females) with no known cognitive deficit; the third group (MCI) comprised 10 elderly individuals (average age of 76.8 ± 5.96; 5 females) with a diagnosis of MCI.

Each patient underwent a clinical interview and physical examination on the same day of enrollment. The study was conducted according to the guidelines on biomedical research involving human subjects (Declaration of Helsinki). Informed consent was obtained from each patient. The inclusion criteria of patients with MCI were cognitive impairment of >6 months and <10 years, and Mini Mental State Examination (MMSE) score of >23/30 and <27/30. This score of MMSE identifies subjects with probable MCI and corresponds to the score of 0.5 (borderline cognitive function) of the Clinical Dementia Rating Scale (Folstein, Folstein, & McHugh, 1975). Exclusion criteria were: neurologic diseases, assumption of antidepressant and anxiolytic drugs and experience as a musician.

Each individual underwent neuropsychological evaluation and underwent two separate sessions of musical exposure. Each session was split into two stages: