The Mozart Effect: Neurological Miracle, Artefact or Suggestive Influence

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Abstract: In its basic form, the Mozart effect refers to a temporary increase in the visual-spatial tasks performance, following the exposure to Sonata for Two Pianos in D major (K. 448) by Mozart. These results have stirred a scientific, social and commercial interest. Despite their popularity, the initial findings have proved to be very difficult to replicate, generating numerous conflicting results. In this paper we have developed a synthesis of the scientific data on this subject, in a new attempt to explain what lies beyond this controversial concept.

Keywords: Mozart effect, spatial reasoning, priming, suggestion

1 Introduction

In 1993, Rauscher, Shaw and Ky carried out a study suggesting that subjects recorded higher scores on the spatial-reasoning subtest of the Stanford-Binet Intelligence Scale, immediately after listening to Sonata for Two Pianos in D Major by Mozart (K. 448) [1]. The phenomenon found at the time was popularized in specialised literature and in popular media as the Mozart effect. The authors reported transient differences of 8-9 IQ points between the subjects' scores after they had listened to Mozart, compared to the scores obtained after listening to a tape of relaxation instructions or after a 10 minutes time of silence. They explained this phenomenon by a priming activation of the neural pathways responsible both for processing complex musical tunes and for some spatial tasks [1][2]. Starting from this interpretation, later studies supported the importance of correlating sciences teaching in schools with the exposure to excerpts from Mozart for improving school results in subjects such as maths [3] [4] [5]. Studying further, Shaw tested the clinical implications of the Mozart effect. He evaluated the results of patients with Alzheimer's disease in performing visual-spatial tasks after listening to Mozart's K448 sonata [6][7]. Also, he noticed that following the exposure to Mozart, the epileptic patients' crises were considerably reduced [8].

Despite the consistently positive results provided by its promoters, the Mozart effect is a controversial concept. There is a number of studies that failed to replicate the initial results [9] [10][11] [12] [13] [14][15][16][17][18][19]. This is greater than the number of studies supporting them [20] [21]. Not only the results are contradictory, but also their associated explanations.

Despite the insufficient validation, the Mozart effect has stirred a growing interest, which is still felt both within the scientific community and by the general public. The aim of our article is to synthesise the existing data in a new attempt to explain what lies beyond the Mozart effect.

2 Is There a Mozart Effect?

The idea to increase the IQ, even on limited areas, by simply listening to classical music, proved to be extremely appealing. The Mozart effect has rapidly grown from a simple scientific hypothesis, into a teaching strategy implemented in schools and sold to the general public. Beyond its mediatic success, an increasing number of studies report the unreality of the phenomenon behind this label.

2.1 Signs of the Mozart Effect Existence

Even before the Mozart effect was proposed as a research hypothesis, the positive effects of various musical stimuli had been studied in relation to learning, task performance and stress reduction [22][23][24]. However, the research supporting the

existence of the Mozart effect often describes definitions, methodologies or different effects under the same name. For instance, significantly improved maze learning results were recorded for rats which had been intrauterinely exposed to sonata K448 [25]. Other researchers have evaluated the role of mode and tempo in stimulating task performance. The cognitive abilities of old adults with moderate cognitive degradation are improved immediately after listening to Mozart's sonata [26]. The beneficial effect remains constant after a musical sessions training conducted over a period of 6 months [27]. The decrease in the number of crises in epileptic patients who listened systematically to sonata K448 is another established effect [8] [28]. These varied results are explained by different specific mechanisms. Using the same concept to name them can unwarrantedly contribute to perpetuating a myth. The same improvised aura, without any scientific evidence, has also led to the mediatic popularity of the Mozart effect. The data have been highly exaggerated and the transient improvement of the visual-spatial performance in some specific tasks, verified only for adults, was used as a significant and stable intelligence improvement in children. A whole industry of books, CDs and various other products was developed by taking advantage of these exaggerations. The climax was reached in 1998 when Zell Miller, Governor of Georgia, decided that each new mother should receive a free Mozart CD, for a good development of the infant's intelligence.

2.2 Signs against a Mozart Effect

Irrespective of the definition, methodology and deliverable result, the Mozart effect has often been refuted by studies aiming to verify it. A meta-analysis conducted on 26 studies concluded that the studies analysed did not support the validity of the Mozart effect. The effect is refuted either by lack of significant differences between experimental conditions, or by the mediating variables that explain better than the neurologic priming theory [29]. Another meta-analysis, more recent and more comprehensive, summarizes the results of 40 studies, showing also the lack of relevant scientific support in the Mozart effect [30]. The conclusion is supported by the reduced effect in case of significant results, the moderating effect of the scientific affiliation determining effect increases of up to three times higher in the studies conducted by Rauscher et al. Similar arguments also mention a study intended for employees in the American education system. The work notices the fact that the Mozart effect has not been observed in enough contexts to prove its reliability. Its presence is neither robust nor systematic. If there is a Mozart effect, it is limited to a very narrow cognitive task, not extended to the entire span of intelligence processes. Thus, the claims that listening to music will improve performance in maths, chess or architecture are completely tenuous [31]. An alternative argument is that the reduced effect of sonata K. 448 may be due to the catchy pace of the musical fragment in an allegro tempo, which stimulates the subjects. In fact, a publishing bias is also mentioned, in that studies showing strong effects in expected directions tend to be published more often, faster and enjoy an increased visibility [30].

3 Explanatory models of the Mozart Effect

The explanatory models of the Mozart effect have emerged naturally from the attempts to replicate the original research. The explanations of the observed phenomena have outlined three important competing interpretations: the neurological priming, the effect of physiological and mood activation, and the effect of suggestion in task directions.

3.1 Mozart Effect as neurological priming

The princeps study on the effect of Mozart's music on a cognitive task did not deal directly with an explanatory model also. The research was aimed at verifying statements already established in this direction. The authors assumed that they observed a priming phenomenon in the neural pathways responsible for processing both complex musical tunes, such as the fragment from Mozart, and some spatial tasks. Once the brain area is activated, subsequent tasks are carried out faster and more fluently [1][2].

Such an explanation completed older information on brain localization. At the moment of this first research, it was known that both the visual-spatial function and the musical ability were located in the right cerebral hemisphere [32][33][34]. Also, it was suggested that listening to music stimulated both alpha and beta brain waves in human subjects [35].

Latest research partially supported the idea of specific brain functionality in producing this phenomenon. A general effect was more easily noticeable. More specifically, it was assumed that

listening to music leads to an increase in the gamma band activity (visible in EEG). This is responsible for the increased activity in certain brain areas, facilitating thus the selection of stimuli and their connection into a perceptual whole. If there is, however, a specific effect, it initiates a series of attentional capacities in certain brain areas that respond to the tasks used in the old experimental paradigms [36]. However, the explanations based on neurological priming contravene the modular cognitive models. They support the independence of the brain areas processing music from the ones intended for other cognitive processes including spatial reasoning [29].

To reconcile the different neurological perspectives, a recent research studied the variables mediating the connection between music practice and intelligence. It resulted that, in a correlational model, the relationship between music lessons and intelligence is mediated, to an extent of 12 to 20%, by the executive functions, and especially by selective attention and inhibition. However, the authors themselves acknowledge that, in the study conducted, the cause can be easily mistaken for the effect. More precisely, we cannot know whether the smarter children will be more inclined to continue taking music lessons or not. Thus, the relationship could be contrary to the one we expected [37].

3.2 Mozart Effect as an Artefact

Numerous studies interpret the positive results of the "Mozart effect" as being explained by preferential and activation differences. It was assumed quite rapidly that the subjects participating in the above mentioned studies go in fact through an increase in the activation status (general arousal). This leads to better performance in the tasks treated as dependent measures. Also, the preference for a piece of music over silence or a neutral noise, can positively modify the mood of the participants, which leads to better results in cognitive tests [38] [26] [20] [39] [40] [41]. Ever since the 2000s, a series of syntheses indicated that the changes noticed in the studies on the Mozart effect can be attributed to increased attention, preference or general activation (effects that can be in fact produced by other stimuli, not just by music) [31].

Another study was aimed at finding the role of the mode (major or minor) and the tempo (slow or fast) on spatial abilities and mood. It was indicated that music in a major mode and a faster tempo was associated with better performance in the spatiotemporal task. Also, significant differences were noticed in the activation state depending on tempo, and in the mood depending on the mode. The results support the theory explaining the Mozart effect by mood and activation changes [26].

Moreover, the assumptions in many of the studies on this topic identify mediating variables to explain the Mozart effect mechanisms. These include improved mood and musical pleasure [29]. In another study, the model supporting the mood activation and improvement effect was partially confirmed; it was shown that exposure to folklore music was associated with increased good humour and preference for the musical fragment [42].

A more recent study raises questions concerning the fact that the experimental history of the Mozart effect is suffering from lack of ecological validity for the situations the subjects participated in. The isolated tasks performed after listening to a short musical fragment differ by far from what we encounter in real life. Thus, the dependent variable used for this study is the performance in a computer game. Between the two groups, manipulation consists in the musical background used during (and not before) the game. Thus, Mozart's sonata was compared to a more modern piece by the Red Hot Chilli Peppers band. The initial hypothesis was that, in fact, a general arousal is determined by the extent to which the subjects' favourite music is used as background. Thus, the authors asked the subjects to rate the degree to which they liked the background music, and also their mood after the game. The authors have found that the subjects who listened to the modern band recorded significantly better results than those who listened to the sonata. The preference for a song or for the other influenced significantly the performance in the game. The authors conclude that the phenomenon is an effect of mood and of the general degree of arousal [43].

A more recent meta-analysis, more attentive to publication biases concludes that when sonata K.448 precedes a cognitive task, its effect is reduced and comparable to the effect of other musical pieces. The reduced effect of sonata K.448 can be attributed to the fact that Mozart's musical piece (allegro) is more entertaining than most alternative musical pieces used in studies [30].

A revealing study by a Thai researcher used 24 subjects in four experimental conditions, combining two very different musical pieces (the well-known Mozart K.448 allegro and Albion - Adagio in G minor for strings and organ). The researcher uses PMOS (Profile of Mood States) an instrument composed of two subscales: Vigor - Activity and Depression - Dejection. The hypothesis was based on the idea that a more lively song will induce a stronger activation status and a better mood than a

slow song. As expected, given the obvious difference between the two musical pieces (Mozart's piece is alert and cheerful, while Albioni's is dramatic and slow), there were differences in the general level of activation and mood. Mozart's piece generated higher scores on the Vigor subscale, and Albioni's piece on the Depression subscale. The results indicate that the so-called Mozart effect is an artefact of the general arousal and mood induced by the musical piece [44].

3.3 Mozart Effect as Suggestion

Suggestion is a form of communication where a person (the suggestor) influences, intentionally or not, another person (the suggestant) by means of verbal communication, non-verbal behaviour and / or other contextual factors. Thus, without acknowledging it, the suggestant takes over the suggestor's intentions, feelings, beliefs or desires in a process that relies on the automatic activation of the former's structures of meaning. The idea communicated by suggestion is accepted in a semi-automatic and non-judgemental way. The suggestive influence does not use verbal arguments, being entirely different from persuasion [45].

The idea that a suggestion can be inserted in the task directions, in such a way as to modify the subjects' performance, was early exploited. In an interesting 1986 study, the male subjects were told to look at a pink screen while exerting force on a dynamometer. One group was told about the experimenter's belief that pink will reduce their physical strength, while the other group was told that pink will help increasing it. Significant differences were recorded between the two groups [46]. Anticipating a similar pattern regarding the Mozart effect, a first attempt to explain the role of the subjects' expectations generated an interesting result. Besides the fact that there were no differences depending on expectations, a variety of conditions have generated improved performance, not only the Mozart musical fragment [47].

However, in another experimental study from 2008, some Canadian researchers investigated the role of task directions in the production of the alleged Mozart effects. More specifically, researchers expected that, once the subjects knew or guessed the effect that music could have had on their performance on a task, they acted as such. As dependent measures, they set the scores to a spatial IQ test and the Differential Aptitudes Tests results. Also, after the experiment, the subjects were asked to provide their own reports on how happy and relaxed they felt. The authors' hypothesis was that positive expectations would lead to better results, while negative expectations to bad results. In an ingenious way, the three authors managed to introduce the independent measure in the informed consent. They used, in the task's directions, phrases like *"in this study we are interested in the beneficial effects music of on ...."* or, on the contrary *"in this study we are interested in the harmful effects of music on ...."* or no phrase related to the effect of music.

The subjects were exposed, under within conditions, to a sonata, complete silence or ... white noise. The three authors were not able to find any effect of sound, the skills subset or even the genre. However, the effect of the directions was significant, leading to a nonlinear relation. Contrary to the hypothesis, the neutral directions determined the group with the best results compared to the two other independent groups. A second experiment used physical strength as dependent variable and obtained similar conclusions.

The authors conclude that there is no Mozart effect. This is a false phenomenon induced by the task instructions and the subjects' compliant participation. It seems that when, unwillingly, the experimenter warns the subjects about the possible relation between music and task performance, his warning significantly influences them. The subjects expect a series of results, and these results contaminate the distribution of scores on the dependent variable. This completely uncontrolled effect can explain the results both for and against the existence of the Mozart effect [48].

4 Conclusion

Since 1993, the media and the recording industry have exploited the idea that Mozart's music improves people's intelligence at all ages, especially in the case of children. Although there is no absolute consensus, studies show that there is no specific effect of Mozart's music on the cognitive tasks performance. The stimuli induced by Mozart's music may be also induced by other musical pieces or even by other stimuli. Its effects are non-specific.

An entire paradigm in musical education was built around the idea that music makes you smarter. This paradigm seems to lead to the impression that music should justify its presence in the curriculum by the secondary benefits it could bring, and not by itself [49]. In fact, *"music is not a means to an end, but an end in itself; music has value in and of itself. Its fundamental worth is not defined by non-musical results"* [50] (p. 3).

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