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The Mozart Effect: Evidence for the Arousal Hypothesis

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Summary

This study investigated the effect of music listening for performance on a 25-question portion of the analytical section of the Graduate Record Exam by 72 undergraduate students (M age 21.9 yr.). Five levels of an auditory condition were based on Mozart Piano Sonata No. 3 (K. 2811, Movement I (Allegro); a rhythm excerpt; a melody excerpt; traffic sounds; and silence. Participants were randomly assigned to one of the stimuli. After a 5-min., 43-sec. (length of the first Allegro movement) listening period, participants answered the questions. Analysis indicated participants achieved significantly higher mean scores after all auditory conditions than those in the silent condition. No statistically significant pairwise mean difference appeared between scores for the auditory conditions. Findings were interpreted in terms of an arousal framework, suggesting the higher means in all auditory conditions may reflect immediate exposure to auditory stimuli.

Since Rauscher, Shaw, and Ky (1993) published their findings on the Mozart effect, the idea that listening to classical music can increase one's cognitive performance garnered mainstream media attention and fueled subsequent scientific inquiry. Despite the ongoing debate, the notion that "music makes you smarter" appears to be a widely accepted misinterpretation of very limited data, which initially only suggested that university students who were exposed to 10 min. of passive listening to one specific composition by Mozart exhibited moderately better spatial-temporal reasoning for a 10- to 15-min. period after listening. One explanation for this temporary increase in spatial-temporal reasoning was that exposure to the sonata facilitated moderate arousal that improved cognitive performance. The present study investigated the explanation of higher cognitive performance after arousal by observing effects of several auditory stimuli on a different type of cognitive task.

Many studies have been conducted to replicate the originally reported Mozart effect as well as to investigate the effects of different types of auditory stimuli on broader measures of intelligence. The Mozart effect has been replicated using the same piano sonata (K. 448) and the same measure of spatial temporal intelligence (Rauscher, Shaw, & Ky, 1995; Rideout & Taylor, 1997), but many other studies have not produced a Mozart-specific effect (Stough, Kerkin, Bates, & Mangan, 1994; Carstens, Huskins, & Hounshell, 1995; Steele, Ball, & Runk, 1997).

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Some researchers have found other music by Mozart temporarily enhanced spatial reasoning (Lintz & Gadbois, 2003) and so did listening to other styles of music (Rideout & Taylor, 1997).

Several authors have suggested that enhancement of subsequent cognitive functioning may simply be attributed to an increase in arousal facilitated by, but not specific to, exposure to the Mozart piece (Chabris, 1999; Steele, 2000; Thompson, Schellenberg, & Husain, 2001; Lintz & Gadbois, 2003). Chabris (1999) acknowledged that there was a moderate advantage in the Mozart condition, but after a meta-analysis of the 16 papers published at that time, he deduced that it was most likely due to a short-term "enjoyment arousal" facilitated by the music. Nantais and Schellenberg (1999) offered a similar explanation for higher performance on the spatial-temporal task in terms of elevation of mood facilitated via exposure to a preferred stimulus. Instead of using silence or "relaxation" control groups, these authors utilized the reading of a short story by Stephen King, which yielded results similar to those for the Mozart condition. More specifically, there was an interaction between the listening condition and preference, as those who preferred Mozart had higher spatial-temporal task performance after listening to Mozart, and those who preferred the narrated story had higher performance after listening to the story.

In a study which may further illustrate the influence of arousal, Thaut and Hinshaw (1999) used both auditory and visual stimuli and suggested enhanced performance on a spatial task could reflect a priming effect created by the perception of structural changes that take place over the presented stimuli. To isolate and identify the precise properties of each stimulus, which might be involved in the apparent arousal-induced enhancement effect, Thaut and Hinshaw (1999) isolated the specific musical elements and included them as stimulus conditions. They tested the following conditions: (a) Mozart Piano Sonata in D major (K. 448); (b) a rhythmic condition in which rhythmic patterns were presented on an indefinite pitch (drum); (c) a random pitch condition where random pitches were presented at the rate of one tone per second; (d) environmental sounds, including forest sounds, bird calls, and rain showers; (e) 34 color slides of abstract art presented at one slide per 15 sec.; (f) a computer screen saver presenting multicolored, continuously changing geometric patterns; (g) a control condition with no presented stimulus. Each stimulus period lasted 8.5 min. and each participant was tested immediately prior to and following exposure to the assigned stimulus on a series of spatial tasks that required mental rotation and matching of presented objects. Data indicated a significant positive increase in performance on posttest scores for all conditions except control (silence). There was no statistically significant difference between scores in the Mozart condition and any of the auditory conditions or the changing visual pattern (screen saver) condition, all of which were considered to have temporal pattern changes in common. Due to the significantly lower performance of the static visual stimulus group (abstract art slides) and the control group, the authors concluded that the observed enhancement effect may have been facilitated by sensory priming based on the perception of temporal change in both complex auditory and visual stimuli and was not specific to Mozart.

If the Mozart effect is indeed a manifestation of arousal or priming as others have posited (Thompson, *et al.*, 2001), then similar increases in performance should be observed not only as a consequence of stimuli other than music, but in areas of cognitive functioning other than spatial-temporal. A language-based dependent variable (the analytic portion of the Graduate Record Exam) was chosen for this study in an attempt to investigate the concept of nontask-specific, arousal-induced performance increases. This study investigated the effect of auditory stimuli on performance under five auditory stimulus conditions: full musical excerpt, rhythm, melody, nonmusical auditory stimulus (city traffic), and a control (silence) condition. Since previous studies have found significant results using different auditory stimuli (Thaut & Hinshaw, 1999; Lintz & Gadbois, 2003), a Mozart piece different from the typical K.448 was utilized. It was hypothesized that there would be differences in test scores due to an arousal effect created by the perception of the more complex, temporally organized nature of the stimuli as compared to the less organized conditions of traffic noise and silence.

METHODS

Participants

Seventy-two participants were recruited on a volunteer basis from undergraduate classes at a large western U.S. university. The 40 men and 32 women ranged in age from 18 to 51 years (*M* age=21.9). None of the participants had prior exposure to any portion of the GRE in any format, thus controlling for practice effects. Also, all of the participants could be considered nonmusicians, having had less than one year of formal training or performance within the last five years. Because musical training has been shown to have a significant influence on the way one processes music, the present study involved only nonmusicians (Gaser & Schlaug, 2003; Fujioka, Trainor, Ross, Kakigi, & Pantev, 2004).

Materials

The musical excerpts were produced using Band-in-a-Box Version 8.0 MIDI sequencing software. The full musical excerpt consisted of the Mozart Piano Sonata No. 3 in B Flat, K. 281: I. Allegro, which lasted for 5 min. 43 sec. The melody condition consisted of the exact ordering of pitches or tones from the Mozart melody, with the rhythmic component extracted. The pitches were presented at a rate of two per second at an even volume level so that there was no apparent rhythmic grouping of sounds in the presentation. The rhythm condition consisted of the exact rhythm from the full Mozart piece presented on a single pitch (E4) to eliminate any tonal contour or shaping. All three musical excerpts were presented using a digitally sampled and produced piano sound (General Midi patch 001) from an Ensoniq TX3 digital keyboard. The auditory nonmusical stimulus consisted of traffic noises from track 1 of the compact disc *Sound Effects Ambience: Internal/External* (TRCD-923, Total Recording Co. Ltd., 1989). These excerpts were recorded to audiocassette tapes and presented to the participants via an AIWA model TX406 portable cassette player with headphones.

Testing resources consisted of a 25-question portion of the analytical section of the Kaplan practice GRE (Chen & Hurlburt, 2000) exam in the written format. The following question is an example from the exam:

If you stop in the movie studio's commissary during lunch-time, you may be able to meet the actors. Although the actors always eat elsewhere on workdays when the commissary does not serve fish, they always eat there on workdays when the commissary does serve fish. If all the statements above are true, and it is true that the actors are eating in the commissary, which of the following must also be true?

(A) It is not a workday, or the commissary is serving fish, or both
(B) It is a workday, or the commissary is serving fish, or both.
(C) It is not a workday and the commissary is not serving fish.
(D) It is not a workday and the commissary is serving fish.
(E) It is a workday and the commissary is serving fish.

Procedure
A between-groups design was utilized to compare all auditory conditions to the control condition and to compare all auditory conditions with each other. The dependent variable consisted of the performance results expressed as the percentage of correct responses on the analytic section of the GRE Kaplan practice test (Chen and Hurlburt, 2000). The participants were randomly assigned to one of five listening conditions. There were (a) 15 participants in the full Mozart piano condition, (b) 15 participants in the rhythm condition, (c) 13 participants in the melody condition, (d) 13 participants in the traffic condition, and (e) 16 participants in the silence condition. After exposure to 5 min. 43 sec. of listening or silence, participants began taking the GRE Kaplan practice test. Participants were given a maximum of 30 min. to complete the 25 questions, which was consistent with the time allotted by the Kaplan GRE practice exam instructions.

RESULTS

For final data analysis, one participant in the silence condition had a score of 84%, which exceeded four standard deviations from the mean (M=31.2; SD= 12.8). Due to the divergence of one score from the mean in the silence condition only (not the entire data set), this score was considered to be a statistical outlier and excluded from further analysis. The authors speculate that the outlying score may be related to very high IQ. The number of test scores included in final data analysis was N=71. Descriptive statistics are shown in Table 1.

TABLE 1
MEAN PERFORMANCE SCORES AS PERCENTAGE CORRECT BY CONDITION

	Full Mozart	Rhythm	Melody	Traffic	Silence
n	15	15	13	13	15
GRE					
M	56.3	47.5	48.6	48.3	31.2
SD	11.0	10.5	15.2	13.3	12.8

A one-way analysis of variance identified a statistically significant main effect for auditory conditions (F, 66= 8.02, p < .00l; *n;* = 327). The statistical power for the main effects was found to be quite high (.997). A Tukey HSD post *hoc* test was performed to determine which auditory conditions were significantly different. Mean scores in the Full Mozart, Melody, Rhythm, and Traffic noise conditions were found to be significantly higher than the mean score for the silent condition (p < .001; see Table 1). No other statistically significant differences were found among the means of the auditory conditions. Effect sizes were found to be negligible for the Melody, Rhythm, and Traffic noise conditions; however, the Full Mozart condition accounted for 4.1% (7; = .041) of the total variance in the test scores, and the silence condition accounted for 16.4% (7; = .164) of the total variance in test scores.

DISCUSSION

Results of this study indicated that a short listening period of either musical or auditory nonmusical stimuli immediately prior to the task resulted in improved performance on the analytic portion of the GRE. The hypothesis that pairwise differences would be observed in favor of the Full Mozart excerpt was not confirmed. In fact, there were no statistically significant differences found among any of the auditory conditions in relation to mean test scores. In short, these data do not support a Mozart-specific effect, as individual elements of music (rhythm and melody) and nonmusical auditory stimuli (traffic sounds) yielded an effect of similar size as the full Mozart piano sonata. It appears that the effect is not exclusive to Mozart specifically or to music generally.

The observations of this study agree with previous findings. Thaut and Hinshaw (1999) and Nantais and Schellenberg (1999) also found that the enhancement effect observed in their studies was not specific to Mozart or even to music, as rainforest sounds and story narration, respectively, similarly improved test performance to music conditions. Thaut and Hinshaw (1999) attributed this to arousal on sensory priming and Nantais and Schellenberg (1999) attributed this to arousal and elevated mood facilitated via exposure to a preferred stimulus. However, Rauscher, *et al.* (1993, 1995) proposed that the enhancement effect found in their studies was due to residual brain activity in those areas shared by both music and spatial processing, due to cerebral activation caused by prior exposure to music. Rauscher (1999) has stated that a problem with designs that have failed to replicate the Mozart effect was the use of invalid dependent variables, that is, those that were not consistent with spatial-temporal functioning, thus not utilizing brain activity in areas shared by both music and spatial reasoning. Steele, Bass, and Crook (1999) and Lintz and Gadbois (2003) would seem to have eliminated this possibility by using the same dependent measures. A need for another mechanistic description seems evident and several have offered arousal and mood as such potential mechanisms (Chabris, 1999; Steele, Dalla Bella, Peretz, Dunlop, Dawe, Humphrey, *et al.*, 1999; Thompson, *et al.*, 2001; Lintz & Gadbois, 2003). Although mood was not evaluated in the present study, this does not seem to be a likely explanation for the results, as the rhythm and melody (and possibly the traffic) conditions may not be described as pleasing due to their monotonous and highly repetitive structure. Berlyne (1971) described how very low or high arousal impedes cognitive performance, whereas more moderate or "homeostatic" arousal improves cognitive performance. It would seem more logical to conclude that the higher test scores found in the present study were more directly the result of elevated arousal and not necessarily to related mood, although as mentioned, mood was not evaluated.

Some limitations of the present study should be reviewed. Clearly mood should have been evaluated, although initially it seemed unnecessary given the rationale that the full Mozart piece would be preferable to simple repetitive subsets of its elemental structures. Modifications to design may also help support the claim that the results are due to overall arousal instead of being stimulus and task-specific. A pretest-posttest design or an assessment of the performance over time may be useful. The inclusion of a variety of tasks including both spatial and language-based tasks in a within-subjects design may more robustly support the notion of arousal-based performance enhancements.

Despite these limitations, the results of the present study indicate no evidence for a Mozart-specific or even music-specific effect on verbal analytic cognitive functioning. The findings of the present study are interpreted through an arousal framework and seem to follow the line of reasoning described by Chabris (1999); Steele, Dalla Bella, Peretz, Dunlop, Dawe, Humphrey, *et* al., 1999; Thaut and Hinshaw (1999); Thompson, *et* al. (2001); and Lintz and Gadbois (2003). Brief exposure to auditory stimuli may be followed immediately by higher functioning on a complex verbal analytic task.

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