Music listening and cognitive abilities in 10- and 11-year-olds: The Blur effect

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Abstract

The spatial abilities of a large sample of 10- and 11-year-olds were tested after they listened to contemporary pop music, music composed by Mozart, or a discussion about the present experiment. After being assigned at random to one of the three listening experiences, each child completed two tests of spatial abilities. Performance on one of the tests (square completion) did not differ as a function of the listening experience, but performance on the other test (paper folding) was superior for children who listened to popular music compared to the other two groups. These findings are consistent with the view that positive benefits of music listening on cognitive abilities are most likely to be evident when the music is enjoyed by the listener.

Keywords: music and cognition, the Mozart effect, arousal and cognition, mood and cognition

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The finding that listening to music composed by Mozart leads to improvements in spatial abilities (1) generated widespread interest among the media, policy makers, and the general public.(2, 3) Interest among the scientific community in the so-called *Mozart effect* was scattered in comparison. One reason for the initial lack of scientific interest was that the mechanism said to be driving the effect was more or less miraculous. As articulated in the original authors' *Trion model*,(4, 5) cortical firing patterns arising from passive listening to complex music (such as that composed by Mozart) were said to be virtually identical to those that arise from tasks that require spatial-temporal reasoning. In other words, the model hypothesized intimate links—as exemplified by identical cortical activity—between domains that have no obvious connection.

It is not surprising, then, that many researchers failed to replicate the Mozart effect.(6) Nonetheless, there have also been many successful replications in independent laboratories,(7) which indicate that the effect is real but somewhat ephemeral. As such, the phenomenon needs a better explanation than that offered by the Trion model. A reasonable alternative is provided by the *arousal and mood hypothesis*,(8) which considers the link between listening to Mozart and spatial-temporal abilities to be just one example of a pleasant stimulus that can improve a perceiver's emotional state, which can, in turn, affect cognitive performance. From this perspective, the link between music and cognition is mediated by changes in listeners' arousal levels and moods. Accordingly, any pleasant or enjoyable musical or nonmusical stimulus that enhances arousal and mood could also enhance cognitive abilities. In contrast to the Trion model, the arousal and mood hypothesis does not give special status to music composed by Mozart, music in general, or to spatial-temporal abilities.

In line with this perspective, enhancement in spatial-temporal abilities has been observed after participants listen to music other than Mozart, including Schubert,(9) Bach,(10) and Yanni.(11) In each instance, the comparison condition consisted of simply listening to nothing (9, 10) or to relaxation instructions (11)—sometimes in groups (10, 11)—which would be much less stimulating than listening to music. When the comparison condition involved listening to a nonmusical auditory stimulus of similar interest (e.g., a narrated story), the music advantage disappeared.(9) Instead, participants performed better after hearing the stimulus (music or story) they preferred. When the musical stimulus was a slow and sad sounding classical piece (i.e., Albinoni's Adagio), the effect also disappeared, as one would expect if arousal and mood are the mediating factors.(8) Finally, when changes in arousal and mood from pre- to post-listening were measured and held constant, the cognitive benefits of listening to fast and happy sounding music composed by Mozart were greatly reduced in one instance,(12) and eliminated in another.(8)

Benefits of music listening also extend beyond measures of spatial-temporal ability, as one would expect from previous research on other stimuli (e.g., a cup of coffee, a small gift) that cause changes in arousal levels or moods and, consequently, changes in a variety of cognitive abilities.(13, 14) In a recent study,(15) undergraduates listened to Mozart (i.e., up-tempo music in a major key) or to Albinoni (i.e., slow music in a minor key) before completing one of two subtests from the Wechsler Adult Intelligence Scale—Third Edition,(16) neither of which measured spatial-temporal (or spatial) abilities. When the two music-listening experiences elicited reliable differences in arousal and mood (favoring Mozart), a reliable difference on one of the subtests was also evident (favoring Mozart). Failure to find an effect on the second test indicates that changes in arousal and mood may be more influential for some cognitive tasks than for others, but a task's "spatial-temporal" status is irrelevant to this distinction.

In another experiment,(15) the creativity of Japanese 5-year-olds was tested after the children *listened* to Mozart, Albinoni, or familiar children's playsongs, or after they *sang* familiar songs. The prediction was that exposure to the children's music would be more enjoyable among these youngsters, such that their creativity would be enhanced compared to the children who listened to classical music. Indeed, the children who heard or sang familiar songs drew for longer periods of time, and their drawings were judged by adult raters to be more creative. In sum, much of the available evidence is consistent with predictions from the arousal and mood hypothesis. Music that is pleasant and enjoyed by a particular listener is the most likely to have positive impacts on the listeners' emotional state, and positive influences on emotional state can improve cognitive performance.(2, 3)

In the present report, we sought to replicate and extend these findings by re-analyzing data collected previously from a large sample of 10- and 11-year-old children. In 1996, Hallam (17) tested over 8000 children residing in the UK. The study was conducted in collaboration with the British Broadcasting Corporation (BBC) a few years after the publication of the original Mozart-effect report. It was designed to test predictions of the Trion model with children, specifically that their cognitive performance would be enhanced after listening to music composed by Mozart compared to control conditions that involved listening to popular music or to a discussion about the experiment. The children completed two spatial-temporal tasks after being assigned at random to one of three listening conditions. As if turns out, absolute levels of performance for the Mozart group were either lower than (on one test) or identical to (on another test) the comparison groups. This failure to replicate the Mozart effect was reported immediately (the day after) on BBC television. The null findings were also published (in 2000) in an outlet that is unavailable to the scientific community at large.(17)

From the perspective of the arousal and mood hypothesis, however, cognitive performance should be best for the children with optimal arousal levels and mood, which would be a likely consequence of the most pleasant and enjoyable listening experience. In our view, the popular music would undoubtedly be the most enjoyable listening experience for this particular age group. We also doubted that listening to Mozart would be particularly pleasing to the children's ears. Accordingly, we re-analyzed Hallam's data with two specific, orthogonal predictions: (1) performance on the spatial tasks would be better after listening to familiar popular recordings than after listening to a piece by Mozart or to a discussion about the experiment, and (2) performance would not differ between the Mozart and discussion groups. This re-analysis was motivated by the large sample size, an alternative hypothesis that emerged after the data were initially collected, and the fact that the earlier report, with its null findings, was published in a journal that is difficult for scholars to access. Although the collaboration with the BBC and the sheer scale of the project meant that the study was not as well controlled as it could have been if listeners had been tested individually in a laboratory, the huge sample size should maximize power to detect an effect if it exists.

Method

Participants

The participants were 8,120 10- and 11-year-olds recruited from schools in the UK. In March of 1996, the BBC undertook a large-scale publicity campaign aimed at recruiting schools to participate in a study that was designed to provide a test of the Mozart effect. The results were to be presented immediately afterward on the television program *Tomorrow's World* (BBC 1). Over 207 schools agreed to participate. These schools were distributed widely throughout the UK. The sample comprised all of the children in Year 6 (corresponding to fifth grade in the U.S.

in terms of age) at each of the participating schools. The number of children from each school ranged from 6 to 142, with an average of 39 children from each school.

Measures

The outcome measures were two, 20-item paper-and-pencil tests of spatial abilities (18) obtained by the BBC from the National Foundation for Educational Research, a non-profit, independent, research institution based in the UK. One test was *square completion* (Figure 1, upper panel), a task that involves deciding whether two line drawings can be assembled to form a square (as in a jigsaw puzzle). On each trial, the participant sees a square (labeled A), a second enclosed line drawing (labeled B) with area less than A, and five possible options for C. The figures are positioned with mathematical signs indicating that A = B + C. The participant's task is to select the option for C that will form A when combined with B. The options for C can be rotated or flipped, or both.

The second test was *paper folding* (Figure 1, lower panel), a task similar to the paper-folding-and-cutting task that has been used widely in previous research.(1, 5, 8, 9, 12) On each trial, participants view line drawings of a square piece of paper being folded in half vertically and horizontally, so that the folded square is one-quarter of its original size. Sections are then cut out of the folded square. The participants' task is to indicate which of four options represents the piece of paper when it is unfolded.

Procedure

At each school, all children in Year 6 were divided at random into three groups of approximately equal size. Each group was assigned to a different room where they had one of three 10-min listening experiences. The listening stimuli were broadcast simultaneously on three different BBC radio stations at 11:00 on the morning of Thursday, March 21st, 1996. One of the groups listened to contemporary pop music on BBC 1, which included three recordings that were popular at the time: *Blur*-"Country House," *Mark Morrison*-"Return of the Mack," and *PJ and Duncan*-"Stepping Stone" (an updated recording of *The Monkees*' song from 1967). A second group heard the last 10 minutes of Mozart's String Quintet in D major K593 on BBC 3, and a third group listened to the second author discussing the experiment with a journalist on BBC 5. After the listening experience, all of the children completed the square-completion test followed by the paper-folding test.

The teachers graded the tests immediately afterward and faxed the results to the BBC, who then forwarded them to the research team. Each child had two scores that could range from 0 to 20, based on the number of items answered correctly. The results were initially summarized and presented on television on Friday, March 22nd, the day after testing. Although the large sample and short timeframe would undoubtedly involve some human error (e.g., in marking the tests, data entry, and so on), such errors should be distributed at random across the three conditions and should not affect the results in a systematic manner. Data from five children with impossible scores (i.e., > 20 on either test) were excluded from analysis.

Results

Because the two tests had a different number of response alternatives on each trial (i.e., square completion had 5, paper folding had 4), chance levels of responding differed between tests. Accordingly, scores were corrected for chance for each child separately for both tests by converting them to adjusted proportions, with the expected value of chance performance subtracted from both the numerator (number of items answered correctly) and the denominator (total number of items). After this transformation, scores on both tests were on the same scale, with a score of 0 corresponding to chance performance and a score of 1 indicating perfect performance. Means and standard errors are illustrated in Figure 1.

As one would expect, children who scored higher on one test also tended to score higher on the other test, $r = .50$, $N = 8115$, $p < .0001$. Nonetheless, 75% of the variance in either test was independent of variance in the other test. Differences between the three groups of children were analyzed initially with a 3 X 2 mixed-design analysis of variance that had one between-subjects variable (listening experience) and one within-subjects variable (spatial test). In general, the children found the square-completion task easier than the paper-folding task, $F(1, 8112) = 511.15$, $p < .0001$. A significant two-way interaction revealed that differences among the three groups of children varied across the two tests, $F(2, 8112) = 3.29$, $p = .0374$. Follow-up planned comparisons indicated that there were no differences among groups on the square-completion task, *F*s < 1. For the paper-folding task, however, response patterns were consistent with predictions. The group who listened to popular music performed better than the other two groups of children, $F(1, 8112) = 5.22$, $p = .022$, who did not differ, $F < 1$. In sum, although the listening experience had no effect on performance for one of the spatial tests, the predicted "Blur effect" was evident for the other test.

Discussion

We re-analyzed data from over 8,000 10- and 11-year-old children who were asked to complete two spatial tests after they had one of three 10-minute listening experiences. Whereas Hallam (17) concluded that these data provided no support for a Mozart effect (as predicted by the Trion model), our re-analysis uncovered a Blur effect (as predicted by the arousal and mood hypothesis) for one of the tests. Children who listened to popular music by Blur and two other artists performed better on a subsequent paper-folding task compared to their counterparts who listened to Mozart or to a discussion about the experiment. On the square-completion task, however, mean levels of performance were virtually identical across the three groups.

These results provide additional evidence that is consistent with the arousal and mood explanation of the Mozart effect. In particular, the findings confirm that the type of music needed to generate cognitive benefits depends on the particular listener. Considering the literature as a whole, there is now evidence of a play-song effect for 5-year-olds,(15) a Blur effect for 10- and 11-year-olds, and Mozart,(1, 7-9, 11, 12, 15) Schubert,(9) and Yanni (11) effects for adults. The comparison condition also matters.(9) For example, many listening experiences—musical or nonmusical—would be more pleasant and engaging than sitting in silence. As such, a previous finding of Bach and Mozart effects among 10- to 12-year-old Australian children (10) is not likely to be a consequence of the children enjoying classical music to a great degree. Rather, the control condition (sitting in silence) was probably notable for being boring, possibly even unpleasant.

Why did we find a Blur effect for one outcome measure but not for the other measure? Schellenberg and his colleagues(15) reported a similar pattern of findings, namely an advantage on one IQ subtest after participants listened to Mozart rather than Albinoni, but no such advantage on another subtest. Researchers interested in the interplay between emotion and cognition could explore this issue further in the hope of uncovering task and contextual factors that make some tests more susceptible than others to the emotional state of the participant. One possibility is that such effects are more likely when the task is particularly challenging (see Figure 2). For the present sample of 10- and 11-year-olds, the paper-folding test was more difficult than the square-completion test. Testing order could also have played a role in the present study because the square-completion test was always administered before the paper-folding test. Nonetheless, because effects of music-listening on cognition are known to be temporary,(1) one would predict the exact opposite result if order were to matter (i.e., effects for the first test but not for the second).

In conclusion, our analysis provides further evidence that positive benefits of music listening on cognitive abilities are most likely to be evident when the music is enjoyed by the listener. In fact, although the arousal and mood hypothesis was formulated to explain cognitive benefits of music listening, links between enjoyable music, emotional state, and behavior extend well beyond cognitive abilities. For example, when patients select a piece of music to listen to while undergoing minor surgery, the pain they experience is less than that of patients who listen to white noise or the background sounds of the operating room, and their pain-medication requirements are reduced.(19) In short, positive effects of music listening are far reaching. Although music is not the only stimulus that has positive impacts on emotional state, it may be somewhat special in this regard because music does not have to be digested physically (unlike coffee or medication), no one is allergic to music, and music is easy (i.e., unobtrusive, noninvasive) to administer to oneself and others.

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Figure Captions

Figure 1. Examples of items from the square-completion test (upper) and the paper-folding test (lower). The correct answers are 3 (upper) and 2 (lower).

Figure 2. Children's performance on the square-completion and paper-folding tasks as a function of the prior listening experience.

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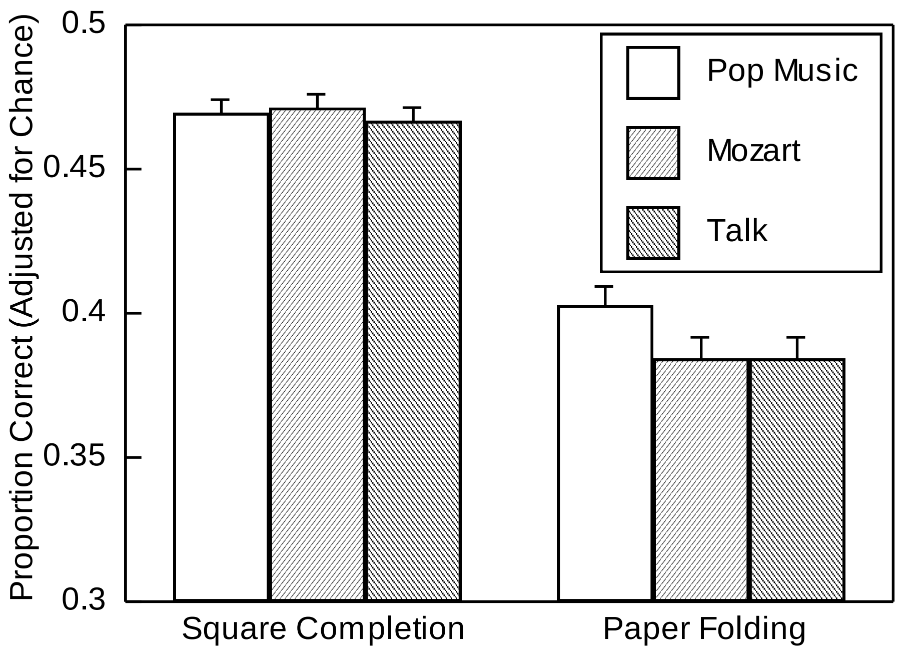

0.5
0.45
0.4
0.35
0.3
Proportion Correct (Adjusted for Chance)
Pop Music
Mozart
Talk
Square Completion
Paper Folding