Psychology of Aesthetics, Creativity, and the Arts
2006, Vol. S, No. 1, 26–32

1931-3896/06/$12.00 DOI: 10.1037/1931-3896.S.1.26

# The Mozart Effect: Arousal, Preference, and Spatial Performance

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A great deal of popular attention has been given to the Mozart effect—an increase in spatial ability following listening to Mozart. Three hypotheses have been advanced to explain this association: Mozart priming the neural pathways used for spatial reasoning, Mozart generally increasing mood and arousal and thus performance, or individuals' preference for Mozart, a different form of music, or even silence leading to an optimal mood for test-taking. The current study sought to differentiate among these three hypotheses. Data were collected from 41 college students (20 male, 21 female) assessed on a spatial relations subtest from the Stanford-Binet following exposure to either music or silence. Participants self-reported how awake they felt and their preference for their particular condition. Results indicated a positive effect of listening to Mozart, although arousal mediated this association. No effect of preference was evident. Implications for theory and application are discussed.

*Keywords:* Mozart effect, spatial ability, arousal, music, intelligence test

An entire industry has sprung from research on the Mozart effect, with companies and parents spending considerable money on CDs and books that suggest listening to Mozart will enhance intelligence. Albums called *Mozart for Mommies and Daddies—Jumpstart Your Newborn's IQ* (Mozart, 1999) and *Brain Boosters for Babies* (Bach, 1999) have been issued, and books have been written that claim Mozart enhances intellectual functioning. These include such titles as *The Mozart Effect for Children: Awakening Your Child's Mind, Health, and Creativity with Music* (Campbell, 2000). The Mozart effect even prompted Georgia Governor Zell Miller to ask the state legislature for $105,000 worth of classical music CDs for the state's newborns, which a record company later donated (Sack, 1998). Unfortunately, the CDs, books, and Governor Miller have misinterpreted the Mozart effect. The Mozart effect does not claim music enhances general intelligence, but rather music temporarily enhances spatial ability. Furthermore, there are no published empirical experiments demonstrating the Mozart effect in infants, although Ivanov and Geake (2003) have reproduced the Mozart effect in primary school children.

The Mozart effect first appeared in a one-page article in *Nature* (Rauscher, Shaw, & Ky, 1993). The study demonstrated that 36 college undergraduates temporarily improved their spatial intelligence after listening to 10 minutes of a Mozart sonata. The authors proposed that merely listening to music had "warmed-up" neurons also used for spatial performance, in this case one's ability to mentally rotate three-dimensional objects (Rauscher, Shaw, & Ky, 1993). The findings were later coined the Mozart effect. It became "omnipresent in U.S. culture, where the media and various interest groups quickly saw in it a new, easy technique for enhancing intelligence" (Bangerter & Heath, 2004, p. 609).

Although the Mozart effect gained notoriety among the general populous, some psychologists (e.g., Nantais & Schellenberg, 1999; Steele, 2000; Thompson, Schellenberg, & Husain, 2001) refuted the original findings and presented competing theories for the Mozart effect. They argued, in essence, that the Mozart effect was merely an artifact of improved test performance and not improved intelligence. These psychologists suggested Mozart optimized testers' mood before solving the spatial problems. Over a decade since the initial findings, psychologists continue to debate the nature of the Mozart effect.

Given the industry and policy decisions surrounding the Mozart effect, it is prudent to differentiate among the various Mozart effect theories. This article seeks to examine the major competing theories of the Mozart effect within a single study. These are (1) a neurological relationship between Mozart and the brain, (2) music influencing arousal prior to testing, or (3) preference for the auditory stimulus affecting test performance, which are discussed in depth below.

## The Neurological Argument for the Mozart Effect

The theoretical basis for the first Mozart effect experiment came from the trion model of cerebral cortex (Leng & Shaw, 1991). The trion model is a mathematical representation of Mountcastle's (1978) columnar model of the cerebral cortex. In the model, similar neural firing patterns occur during spatial-temporal tasks and musical cognition. Leng and Shaw hypothesized that listening to music might therefore activate those neurons prior to completing a spatial task. In other words, listening to music enhances spatial performance by priming specific neurons in the cerebral cortex.

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Portions of this work were presented at the 2005 meeting of the American Psychological Association in Washington, DC. We thank Joyce Alexander, Jonathan Plucker, Gayle Dow, and Claire Tramm for their help in this project. We also thank those who kindly participated in the study, especially Elizabeth Jarchow.

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Rauscher, Shaw, and Ky (1993) supported the biological rationale by improving 36 college students' spatial intelligence scores by 8 to 9 points after they listened to 10 minutes of Mozart's "Sonata for Two Pianos in D Major, K. 448." All of the students participated in three different 10-minute treatments (Mozart, a relaxation tape, and silence). After each treatment, participants answered spatial ability questions taken from the Stanford-Binet intelligence test. Listening to the Mozart sonata produced the highest spatial scores. The authors noted that spatial improvements lasted for 10-15 minutes after hearing the music. Building on these findings, in 1995 Rauscher, Shaw, and Ky confirmed these results by comparing 10 minutes of Mozart to a variety of other musical genres.

In subsequent neurological studies, Rideout and Taylor (1997) and Rideout, Dougherty, and Wernert (1998) compared Mozart to relaxation treatments and Yanni's "Acroyali/Standing in Motion," respectively. In the first study, results suggested Mozart had a greater impact on spatial performance than relaxation techniques. For the second study, a professional musician deemed the Yanni selection similar to the "Mozart piece in tempo, structure, melodic and harmonic consonance, and predictability" (p. 513). Results suggested no difference between Mozart or Yanni's effect on spatial scores, but increases occurred for both treatments. Therefore, Rideout and colleagues hypothesized music similar to Mozart could also positively affect spatial performance by priming the brain for spatial performance, while relaxation would not.

## The Arousal Argument for the Mozart Effect

A competing Mozart effect theory refutes the neurological rationale. Appearing after a series of failed replications (Steele, Ball, & Runk, 1997; Steele, Brown, & Stoecker, 1999), some researchers argued increases in spatial ability merely reflected enhanced test performance, and not an intellectual change. Steele, Bass, and Crook (1999) hypothesized music altered a person's mood, which in turn influenced how the person performed on a spatial intelligence test. To test their hypothesis, the researchers employed two musical pieces. Participants either heard a song by Philip Glass, which they reported as being "repetitive," "obnoxious," and "grating," and the Mozart piece, which participants described "as "lively," "bouncy," and "happy" (p. 367). The researchers then asked participants to describe their mood after taking the spatial test. Results suggested no difference in spatial performance (Mozart or Philip Glass), but those hearing Philip Glass reported higher anger and tension scores.

Steele (2000), therefore, suggested that hearing music affected mood and arousal level, which influenced spatial testing. These findings were subsequently confirmed when participants self-rated their arousal and mood after hearing either Mozart's "Sonata for Two Pianos in D Major, K. 448" or a slow, sad song by Albinoni (Thompson et al., 2001). Results suggested spatial performance improved after listening to Mozart, but not the Albinoni piece. These findings disappeared, however, when researchers held arousal levels constant. As such, Thompson, Schellenberg, and Husain (2001) commented that, "enjoyable stimuli induce positive affect and heightened levels of arousal, which lead to modest improvements in performance. . ." (p. 251). Paradoxically, in the first Mozart effect study, Rauscher, Shaw, and Ky (1993) found pulse rates did not change after listening to Mozart, which they claim dismisses the arousal theory.

## The Preference Argument for the Mozart Effect

Nantais and Schellenberg (1999) suggest improved spatial performance may be the result of a preferred stimulus, not a temporary biological change in spatial ability. Results indicated participants' spatial performance was greater when listening to Mozart than a control group exposed to silence. The researchers also had participants note their preference for either a Mozart sonata or an audio reading of "The Last Rung on the Ladder" by Stephen King. Spatial scores were higher when participants preferred the stimulus, regardless of the actual stimuli.

Another article supporting the preference theory tested primary school children (McKelvie & Low, 2002). The students were exposed to a Mozart sonata, relaxation techniques, and a song from the popular dance group Aqua, which the researchers believed the children preferred (although no preference measurements were taken). Results indicated the Aqua groups scored higher on the spatial task than the Mozart groups or the relaxation treatment. Congruent findings occurred in a second experiment in the study. These results suggest preferred stimuli improved test performance.

## The Current Study

Each theory above offers a rationale for why certain types of music enhance spatial performance. The original researchers believed Mozart "warmed-up," or primed, the same neurological pathways used in spatial tasks. Other Mozart effect investigators believe listening to music enhances test performance by either music optimizing arousal or by optimizing mood for test taking via individuals' preferences for various musical and nonmusical stimuli. Although each theory has its merits, no single study encapsulates all three competing theories. In an attempt to discern between the theories, we examine whether Mozart itself, arousal, or preference most affects spatial performance. These findings have direct implications for parents, policy makers, and the understanding of the effect of music on spatial intelligence.

## Method

### *Participants*

Forty-one college students (21 female, 20 male) participated in the study. Ages ranged from 19 years to 27 years with a mean age of 20 years, 9 months and a standard deviation of 1 year, 9 months. The sample was comprised of thirty-four Caucasian students (82.9% of the sample), three African-American students (7.3%), two Hispanic/Latino students (4.9%), and two nonreporting students (4.9%). All of the participants came from undergraduate educational psychology courses at a large, Midwestern university.

### *Design*

The researchers randomly assigned participants into experimental (listened to Mozart) and control (exposed to silence) groups. The study's independent variables were exposure to Mozart or silence, self-reported arousal, and self-reported preference for the music or silence stimulus. A measure of spatial ability served as the dependent variable.

### Procedure

Researchers informed participants the study involved the relationship between listening to music and problem solving ability. Participants filled out a brief demographic questionnaire. Researchers then randomly assigned the participants into experimental or control conditions. The experimental group stayed in their classroom, while the control group walked down the hallway into a library located in the same building.

A researcher informed the experimental group that they would hear a classical music piece for approximately 7.5 minutes, and while the music played, participants should sit quietly and listen to the music. Students undergoing the experimental condition listened to Mozart's "Sonata for Two Pianos in D major, K. 448" for 7 minutes and 28 seconds (Mozart, 2001). The researchers played the musical piece on a portable stereo or through a stereo already located within the college classrooms. The music's volume was loud enough for all students to hear adequately. At the completion of the song, participants remained sitting and quiet until the control group returned (less than 1 minute).

During the same time, control group members left the main classroom and sat quietly in a nearby library for 7.5 minutes. An experimenter accompanied the control group to ensure participants refrained from talking or working during the control conditions. Although the library was not void of other stimuli (e.g., other students), the researchers deemed the setting appropriate since it was quiet and unlikely to increase much arousal as students routinely passed the library on their way to class. In addition, researchers sat participants away from other students in the library. The control group returned to the classroom at the end of the seven and half minutes. It is possible that walking to and from the library increased arousal, but results presented below refute this possibility.

Once the control group returned to the classroom, all participants self-reported their level of arousal and preference for the condition. Participants then tried answering the spatial relations task. Participants had 30 minutes to answer these questions, but most were finished within 15 minutes. Participants were free to leave after attempting to answer all of the questions.

### Measures

Arousal and preference measurements came from self-reports. Immediately after exposure to Mozart or silence, researchers asked the participants if they felt more awake, less awake, or neither, which served as a measure of arousal. We coded the arousal measure into ordinal data (*more awake* = 3, *neither* = 2, *less awake* = 1). Although this may not be a true biological measure of arousal, existing Mozart effect research has used self-reports (e.g., Thompson et al., 2001) to indicate arousal changes.

Participants then self-reported their preference for the stimuli by answering the question, "Did you like the music/silence that you listened to?" by circling either yes, a little bit, or no. The preference measures were coded into ordinal data (*yes* = 3, *a little bit* = 2, *no* = 1). This parallels existing methods of self-reporting preference in Mozart effect research. This may not be a true test of preference since participants are randomly assigned to a condition and not given personal choice. As such, the preference measurement might instead be tapping into stimulus likeability. Random assignment should lessen this threat by equally distributing a priori stimulus likeability into the experimental and control groups. We will follow existing protocol and refer to participants' self-reports as a measure of preference.

To measure spatial ability, all participants tried solving 17 paper-folding and cutting questions. These items came from the Stanford-Binet Intelligence Scales (4th ed.; Thorndike, Hagen, & Sattler, 1986), which are similar to those used by other Mozart effect studies. The task involves participants imagining a piece of paper being folded several times and shapes being cut out of it. The participant then uses their spatial ability by mentally rotating and unfolding the imaginary paper. The participant must then choose what the paper should look like when unfolded.

## Results

We present three sets of findings. First, we examine whether Mozart or silence directly affected spatial performance. The second set of findings involves the affect of arousal on spatial performance. This includes a path analysis illustrating the relationship between listening to Mozart or silence, arousal, and spatial performance. Third, we analyze the relationship between participants' preferences for the stimuli and improved spatial abilities.

### Mozart Effect

We began data analysis by testing for differences between the Mozart and silence groups. We used an analysis of variance (ANOVA) to see if spatial performance differed between hearing the Mozart sonata or silence exposure. This was a direct test for the Mozart effect and excluded the arousal and preference variables.

Results indicated a Mozart effect, $F(1, 39) = 8.4$, $p = .006$, $d = .91$. The Mozart group scored significantly higher on spatial ability ($M = 14.15$, $SD = 2.46$) than the silence group ($M = 11.33$, $SD = 3.62$). The results of the ANOVA indicated that listening to Mozart enhanced spatial performance, providing tentative support for the original Mozart effect findings.

### Arousal Effect

To test whether music or arousal affected spatial performance, an analysis of covariance (ANCOVA) with music or silence serving as the independent variable and arousal as the covariate was run. In effect, this test would illustrate whether music remained a significant variable above and beyond arousal, or whether arousal explained the impact on spatial performance.

The results of the ANCOVA indicated arousal was a significant covariate, $F(1, 33) = 4.5$, $p < .05$. After controlling for arousal, exposure to Mozart/silence became a nonsignificant main effect, $F(1, 33) = 2.4$, $p = .13$. This result suggested that Mozart or silence did not directly affect spatial performance. That raised the possibility that arousal mediated the relationship between Mozart and spatial performance.

Consistent with this possibility, results suggested arousal levels were significantly different between the music and silence groups, $F(1, 32) = 9.86$, $p = .004$, $d = 1.0$, with the Mozart group having greater arousal ($M = 1.89$, $SD = .66$) than the silence group ($M = 1.27$, $SD = .46$). Only the Mozart group had participants who self-rated their arousal as being more awake ($n = 3$). This group also had the highest average spatial performance ($M = 15$, $SD = 1.0$) among all Mozart and silence participants. On average, the lowest spatial performance came from those exposed to silence and decreased arousal ($n = 11$, $M = 11.36$, $SD = 3.26$). See Table 1 for a breakdown of spatial scores per arousal level category and music/silence exposure.

To further explore how arousal affected spatial performance, a path analysis was conducted by testing a series of simultaneous regression models. All regression parameter estimates (i.e., regression weights, betas) reported below have been standardized. In Model 1, arousal is regressed on the music manipulation variable. The music manipulation is found to be positively associated with arousal, $\beta = .49$, $p = .004$, such that listening to music is associated with higher arousal than is listening to silence. Model 1

Table 1
*Spatial Performance Scores per Arousal Category and Exposure to Mozart or Silence*

| Variable | Less arousal | No change | More arousal |
|---|---|---|---|
| Exposure to Mozart | $n$ = 5 | $n$ = 11 | $n$ = 3 |
| | $M$ = 13.4 | $M$ = 14.00 | $M$ = 15.00 |
| | $SD$ = 3.36 | $SD$ = 2.32 | $SD$ = 1.00 |
| Exposure to silence | $n$ = 11 | $n$ = 4 | $n$ = 0 |
| | $M$ = 11.36 | $M$ = 12.75 | |
| | $SD$ = 3.26 | $SD$ = 2.99 | |

*Note.* Spatial scores are out of 17 possible questions.

establishes a direct relationship between the music manipulation and arousal (see Figure 1). In Model 2, spatial ability is regressed on arousal. Arousal is found to be positively associated with spatial ability, $\beta = .35$, $p = .045$, such that as arousal increases spatial ability tends to increase as well. Model 2 establishes a direct relationship between arousal and spatial ability. In Model 3, spatial ability is regressed on the dichotomous music manipulation variable (*music* = 1 vs. *silence* = 0). The music manipulation is positively related to spatial ability, $\beta = .42$, $p = .006$, such that listening to music is associated with greater/higher spatial ability performance than is listening to silence. Model 3 establishes a direct relationship between the music manipulation and spatial ability.

The music manipulation was found to be positively related both to general arousal and to spatial ability performance, such that listening to music is associated with higher arousal and greater/higher spatial ability. Arousal was found to be positively related to spatial ability performance. Most notably, both the music manipulation and arousal separately predicted spatial ability performance, which suggests that the association between listening to music and spatial ability may be mediated by arousal. To examine this possibility, spatial ability is simultaneously regressed both on the music manipulation variable and on arousal in Model 4 to determine whether the predictive relationship between the music manipulation and spatial ability is mediated by general arousal. Mediation will be demonstrated if the significant relationship between music manipulation and spatial ability (Model 3) is nonsignificant when arousal is added to the model.

In Model 3 above, music manipulation was found to be a significant predictor of spatial ability, $\beta = .42$, $p = .006$. In Model 4, however, with spatial ability regressed on both music manipulation and arousal, music manipulation did not account for a significantly unique portion of variance in spatial ability, $\beta = .29$, $R^2 = .06$, $p = .13$, *ns*. In other words, music manipulation no longer predicts spatial ability performance after controlling for arousal. This indicates that the relationship between music manipulation and spatial ability is mediated by changes in arousal following the music manipulation (also in Figure 1). Furthermore, the overall simultaneous regression model is significant, $R^2 = .18$, $F(2, 31) = 3.46$, $p = .044$. Arousal, however, no longer uniquely predicts spatial ability, $\beta = .21$, $p = .273$, *ns*, after control for music manipulation. In addition, a separate simultaneous regression analysis (Model 5) reveals that the music manipulation still significantly and independently predicts arousal after controlling for spatial ability, $\beta = 41$, $p = .019$. Consequently, this path analysis supports the mediational hypothesis that the music manipulation enhances spatial ability indirectly through arousal because the previously significant predictive relationship between music manipulation and spatial ability, $\beta = .42$, $p = .006$ (Model 3), was reduced to nonsignificance, $\beta = .29$, $p = .13$ (Model 4), after controlling for arousal.

### *Preference Effect*

In examining whether preference affected spatial ability, the first step was to confirm no relationship between arousal and preference. This step was needed to ensure preference was not affected by arousal. Results suggested no relationship between arousal and preference for the stimulus, $r(34) = .16$, $p = .37$. This result illustrated that the preference variable did not correspond with an increase or decrease in arousal. Therefore, the analysis of stimulus preference on spatial performance could focus solely on the preference and exclude arousal.

An ANCOVA with preference serving as the covariate, Mozart or silence as the between groups factor, and spatial performance as the dependent variable was then run. Results indicated preference was not a significant covariate, $F(1, 31) = 1.5$, $p = .23$, nor was exposure to Mozart or silence a significant main effect, $F(1, 31) = 4.03$, $p = .054$. More participants preferred listening to Mozart ($n = 10$) than silence participants preferring their assigned stimulus condition ($n = 2$). Nevertheless, preference did not significantly affect spatial ability. See Table 2 for specific spatial performance scores among the various preference levels.

## Discussion

The present study examined three competing theories for the Mozart effect: a neurological theory, an arousal theory, or a stimulus preference theory. The first theory suggests Mozart "warms-up" a part of the brain used for both musical cognition and spatial ability (Leng & Shaw, 1991). Therefore, passively listening to Mozart might prime key neurological pathways prior to spatial reasoning performance. The initial results supported this theory by reproducing the same Mozart effect found by Rauscher, Shaw, and Ky (1993). This was a simple association, however, and would be truly persuasive only if it withstood tests of potential non-neurological mediators posited by the other theories.

The arousal theory suggests listening to music enhances testing performance by raising levels of alertness. In short, it argues that arousal, as a covariate, mediates the relationship between music

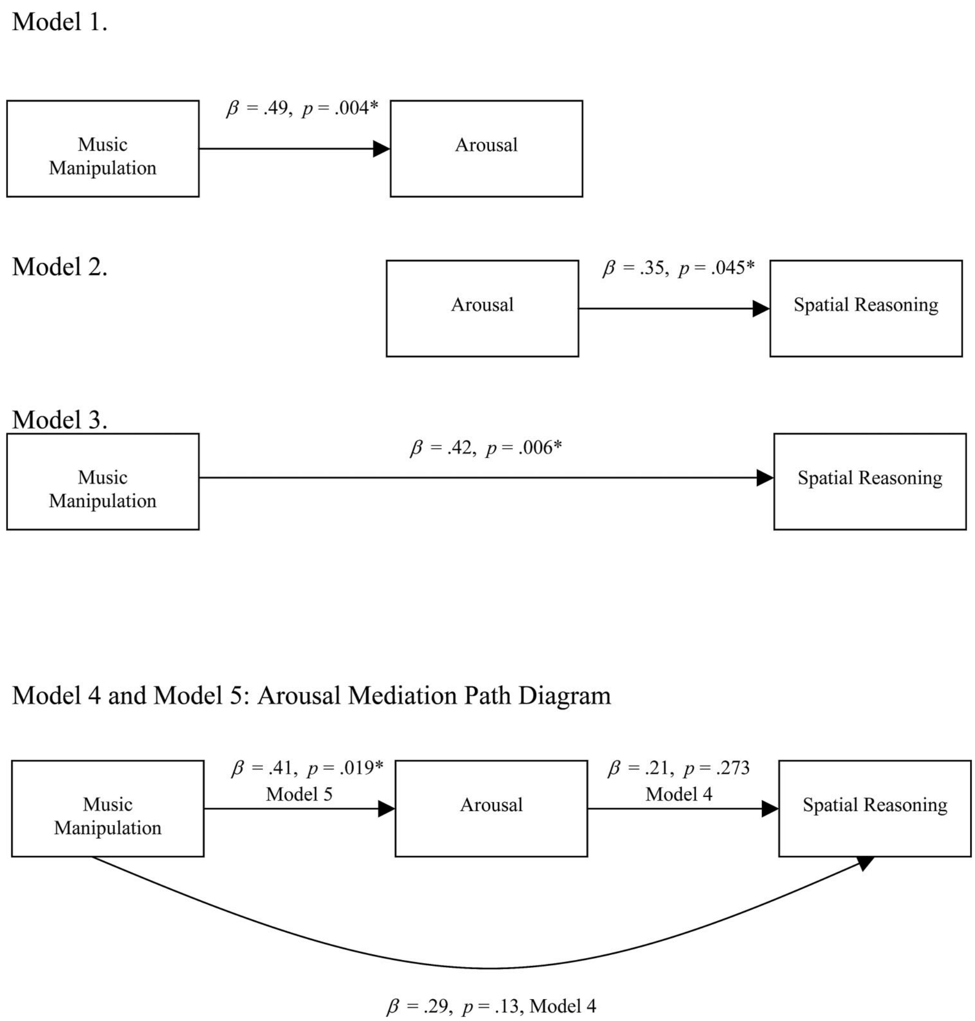


*Figure 1.* Path analysis: Arousal mediated spatial ability following the music manipulation.

and higher spatial test scores (Steele, 2000). In support of this hypothesis, after entering arousal as covariate, listening to Mozart was no longer a significant predictor of spatial scores. As a further test of mediation, the path analysis suggested that music affected arousal, which is itself related to spatial ability (though not significantly once music was partialed out).

Interestingly, Mozart group members who reported no change in arousal scored higher on the spatial abilities test than silence group members reporting no change in arousal (see Table 1). In addition, spatial scores were higher with Mozart group members reporting a decrease in arousal than silence group members reporting a decrease in arousal. Although these findings may be intriguing, and seem to indicate a possible effect of music above and beyond arousal, the differences are not statistically reliable. This is because of small cell sizes and thus compromised power, so any such conclusions are speculative in nature.

The final theory examined whether preference for the stimulus would induce greater spatial performance. Our results were contrary to the theory that stimulus preference had any impact on spatial performance. In addition, preference did not relate to participants' arousal. It is plausible, however, that previous findings supporting the preference theory may have inadvertently tapped into the arousal effect. For instance, McKelvie and Low (2002) found preference influenced spatial performance, but relaxation techniques did not. These participants' arousal levels may have been sufficiently lowered by the relaxation techniques to impede test performance, while the preferred music may have increased arousal.

Our results also undermine the conclusions drawn from studies which compared Mozart to relaxation techniques (McKelvie & Low, 2002; Rauscher, Shaw, & Ky, 1993; Rideout & Taylor, 1997) or depressive music (Thompson et al., 2001). Indeed, relaxation techniques or depressive music likely decreases spatial scores by lowering participants' arousal, and thus the comparison did not in fact rule out an arousal hypothesis. These findings suggest that the more useful basis of comparison should be the opposite; playing more upbeat music should increase arousal, and therefore heighten testing ability in a parallel manner to Mozart.

Our findings build upon existing research on Mozart, arousal, and spatial performance (e.g., Thompson et al., 2001) and further clarify the nature of the relationship between Mozart and spatial ability. Specifically, Mozart may not directly affect spatial ability,

Table 2
*Spatial Performance Scores per Preference Category and Exposure to Mozart or Silence*

| Variable | Preferred stimulus | Indifferent | Disliked stimulus |
|---|---|---|---|
| Exposure to Mozart | $n = 10$ | $n = 6$ | $n = 3$ |
| | $M = 13.6$ | $M = 15.00$ | $M = 13.33$ |
| | $SD = 2.89$ | $SD = 1.67$ | $SD = 2.08$ |
| Exposure to silence | $n = 2$ | $n = 6$ | $n = 7$ |
| | $M = 15.00$ | $M = 10.33$ | $M = 12.00$ |
| | $SD = 2.83$ | $SD = 2.89$ | $SD = 3.06$ |

*Note.* Spatial scores are out of 17 possible questions.

but rather indirectly improve spatial performance by heightening arousal. In addition, music may optimize arousal in order to affect spatial performance, rather than merely increasing it. Past research has indicated an inverted "U" relationship between alertness or anxiety and test performance: too much arousal overstimulates the test-taker, while too little arousal may lead to carelessness and mistakes (e.g., Munz, Costello, & Korabik, 1975). This means different songs and music genres could have differential impacts on test performance, depending on the participants, their arousal level prior to hearing music, and the impact of the music itself. For instance, although our findings showed the upbeat Mozart sonata optimized and positively impacted a group of college students' arousal, the same result may not be found in other populations if they perceived it as boring or outdated music. Further, an increase in arousal from other genres such as punk or "speed metal" might lead to overarousal and compromised performance.

It should be clear that these findings do not suggest that listening to music will improve *all* test performance. This study had participants solve spatial problems, which required minimal preexisting knowledge in order to perform the task. The results therefore indicate music heightens arousal and aids performance on tasks not explicitly measuring learning. It is not immediately clear how music might affect test performance when solving content-based questions. If, however, the Mozart effect is a matter of arousal and not the priming of specific neural pathways, there is reason to believe that it would have a positive impact on general test taking, and not be limited to tests of spatial reasoning.

## Conclusion

The current study's results suggest a pathway for music to affect spatial performance: certain types of music optimize arousal and therefore enhance spatial performance. We did not find sufficient evidence to support the neural priming Mozart effect theory or a stimulus preference theory. As such, there is no reason that parents and policy makers should look to Mozart as an efficacious early intervention to enhancing spatial ability.

On a cursory level, these findings can be interpreted as support for using music to temporarily enhance test performance. Simply, students and others facing impending tests may try listening to Mozart to improve performance. We would like to caution against using these findings in this way. Many other proven methods exist that enhance test performance and spatial talents (e.g., studying and participating in spatially rich activities such as painting). Music might temporarily boost test performance, but there is little reason to expect that passively listening to music will dramatically increase long-term performance. Further, there is little evidence to suggest that these effects would be lasting in adults and none at all that listening to Mozart would affect permanent changes to the developing brain.

Our conclusions also come with some noted limitations. Primarily, we used only one measure of spatial ability and had participants self-report their arousal. We chose to use the paper-folding and cutting task taken from the Stanford-Binet. This subtest parallels measures used in existing Mozart effect research. Although this allows for a comparison between various studies' spatial scores, using only one measure limits the external validity of the Mozart effect findings to other spatial tasks. In addition, the current study's internal validity is affected by participants' self-reports of arousal and preference. Without measuring biological arousal levels (e.g., perspiration), results rely on individuals' self-awareness, which can be imprecise at best. We do feel, however, that self-awareness among college students is sufficient to notice if their arousal has changed.

Additional research is needed to further clarify the relationship between music and spatial performance. Future research is certainly needed given how companies have already profited from misconceptions about the Mozart effect. Future work may help explain the extent to which arousal affects spatial performance among different groups of people, ages, spatial abilities, and musical genres. Apart from two studies (Ivanov & Geake, 2003; McKelvie & Low, 2002), current Mozart effect research has employed mostly Caucasian college students. Future research could focus on the arousal effect among underrepresented groups. A developmental perspective could also be employed to examine how arousal affects spatial performance at different ages. In addition, research might examine how arousal and spatial performance interact among people with high spatial talents (e.g., artists and musicians). Mozart effect research has focused primarily on classical music, but additional studies may shed light on what types of music best affect arousal and spatial performance, and whether music affects performance on other spatial tests. Only through further research will the complexity of the relationships among music, arousal, and spatial performance be fully understood.

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Received April 28, 2006
Revision received April 28, 2006
Accepted April 28, 2006 ■