

Research Report

AROUSAL, MOOD, AND THE MOZART EFFECT

William Forde Thompson,¹ E. Glenn Schellenberg,² and Gabriela Husain¹

¹York University, Toronto, Ontario, Canada, and ²University of Toronto, Mississauga, Ontario, Canada

Abstract—The “Mozart effect” refers to claims that people perform better on tests of spatial abilities after listening to music composed by Mozart. We examined whether the Mozart effect is a consequence of between-condition differences in arousal and mood. Participants completed a test of spatial abilities after listening to music or sitting in silence. The music was a Mozart sonata (a pleasant and energetic piece) for some participants and an Albinoni adagio (a slow, sad piece) for others. We also measured enjoyment, arousal, and mood. Performance on the spatial task was better following the music than the silence condition, but only for participants who heard Mozart. The two music selections also induced differential responding on the enjoyment, arousal, and mood measures. Moreover, when such differences were held constant by statistical means, the Mozart effect disappeared. These findings provide compelling evidence that the Mozart effect is an artifact of arousal and mood.

Rauscher, Shaw, and Ky (1993) reported that college students perform better on standardized tests of spatial abilities after listening to 10 min of a Mozart sonata than after listening to relaxation instructions or sitting in silence. Despite the short-term nature of the so-called Mozart effect (10–15 min), the results received widespread attention in the popular and scientific media (e.g., Holden, 1994; NBC News, 1994). Indeed, the notion that “music makes you smarter” has become one of the most well-known popular interpretations (or rather misinterpretations) of a psychological finding.

Although the Mozart effect has been replicated by the original researchers (Rauscher, Shaw, & Ky, 1995) and others (see Chabris, 1999; Hetland, 2000), failures to replicate the effect raise doubts about its reliability (e.g., Steele, Bass, & Crook, 1999; Steele, Dalla Bella, et al., 1999). Nonetheless, based on a meta-analysis of 16 studies, Chabris (1999) conceded that there may be a small intermittent effect, but that it probably arises from “enjoyment arousal” induced by music. Because sitting in silence or listening to a relaxation tape is less arousing than listening to Mozart, experimental and control conditions in most examinations of the effect may have produced different levels of arousal or mood (Nantais & Schellenberg, 1999; Schellenberg, in press). In other words, previous investigations of the Mozart effect—with one exception—may have confounded differences in listening condition with differences in arousal and mood. Specifically, studies reporting a significant Mozart effect (see Chabris, 1999; Hetland, 2000) used comparison conditions that were less arousing (e.g., sitting in silence for 10 min) and less likely to induce positive mood than listening to Mozart. In the single exception that provided an auditory stimulus of comparable interest and complexity, differences in spatial abilities disappeared (Nantais & Schellenberg, 1999).

It is possible, then, that the Mozart effect has little to do with Mozart in particular or with music in general. Rather, it may represent

an example of enhanced performance caused by manipulation of arousal or mood. Such effects are well established. Very high or low levels of anxiety or arousal inhibit performance on cognitive tasks, whereas moderate levels facilitate performance (Berlyne, 1967; Sarason, 1980; Solomon & Corbit, 1974; Yerkes & Dodson, 1908). Moreover, negative moods and boredom can produce deficits in performance and learning (Koester & Farley, 1982; Kovacs & Beck, 1977; O’Hanlon, 1981), whereas positive moods can lead to improved performance on various cognitive and problem-solving tasks (Ashby, Isen, & Turken, 1999; Isen, 1999).

If the Mozart effect is a consequence of arousal or mood, then similar increases in performance on spatial tasks should be observed following exposure to pleasant and engaging stimuli other than music. Nantais and Schellenberg (1999, Experiment 2) tested this hypothesis by asking participants to complete a spatial task after listening to music by Mozart or a narrated story by Stephen King. They also indicated which listening experience (music or story) they preferred. This alteration to the control condition (i.e., listening to a narrated story instead of sitting in silence) eliminated the Mozart effect. Moreover, a significant interaction between condition and preference revealed that individuals who preferred the Mozart music had improved spatial performance following the music, whereas those who preferred the story improved after the story.

The present investigation is the first to examine directly the contribution of arousal and mood to the Mozart effect. We compared the effects of two musical pieces: a Mozart sonata, expected to induce heightened arousal and positive mood, and an adagio by Albinoni, expected to induce low arousal and sad mood. Spatial abilities, arousal, and mood were evaluated after exposure to each piece, and after a silence condition. Listeners also rated their enjoyment of each piece. We predicted that the effects of music on spatial ability would be attributable to differences in arousal and mood, as well as enjoyment.

METHOD

Participants

The participants were 24 undergraduate and graduate students (20 to 60 years of age) who had 2.75 years of formal music lessons on average ($SD = 6.60$ years; range: 0–30 years).

Stimuli and Measures

The musical excerpts consisted of 10 min from Mozart’s (1985, track 1) Sonata for Two Pianos in D Major, K. 448, or 10 min from Albinoni’s (1981, track 1) Adagio in G Minor for Organ and Strings. The excerpts were digitally rerecorded from compact discs onto the hard disc of a computer without loss of sound quality. For the Mozart sonata, we recorded the entire first movement (8 min, 24 s) and replayed it until 10 min were accumulated. The sound file for the Albinoni adagio was created in the same way; participants heard the entire piece (7 min, 20 s) and a repetition of the early portion.

Address correspondence to William Forde Thompson, Department of Psychology, Atkinson College, York University, 4700 Keele St., Toronto, ON, Canada M3J 1P3; e-mail: billt@yorku.ca.

The outcome measure was a modified version of the Paper Folding and Cutting (PF&C) subtest from the Stanford-Binet intelligence test (following Nantais & Schellenberg, 1999). It consisted of two different 17-item subsets (Sets A and B) ordered from easiest to most difficult. On each trial, participants saw a rectangular piece of paper undergo a series of folding and cutting manipulations. Their task was to choose the correct outcome from five “unfolded” pieces of paper.

Supplementary measures included the Profile of Mood States (POMS)—Short Form (McNair, Lorr, & Droppleman, 1992), which assessed arousal level and mood as determined by scores on the Vigor-Activity and Depression-Dejection subscales, respectively. The POMS consists of 30 adjectives describing feelings and mood. Adjectives in the Vigor-Activity subscale (*lively, active, energetic, full of pep, and vigorous*) describe positive arousal; those in the Depression-Dejection subscale (*sad, unworthy, discouraged, lonely, and gloomy*) describe negative affect. We refer to these scales as *POMS arousal* and *POMS mood*, respectively. We had no predictions for the other subscales (Tension-Anxiety, Anger-Hostility, Fatigue-Inertia, and Confusion-Bewilderment), but we administered the entire form to avoid tampering with its psychometric properties (i.e., its good reliability and validity; see McNair et al., 1992). Participants used a 5-point scale (anchored by *not at all* and *extremely*) to indicate the degree to which each adjective described their mood.

Participants also provided a global rating of mood and arousal on a scale from 1 (*sad*) to 7 (*happy*); we refer to this as the *subjective mood-arousal* rating. Participants were told that any high-energy mood should be placed at the high end of the scale and that any low-energy mood should be placed at the low end of the scale. Thus, feelings of meditation, contemplation, or melancholy would be assigned low ratings. In effect, the subjective mood-arousal rating combined mood and arousal into a single measure, providing a global but subjective counterpart to the POMS measures. (No participant reported difficulty using this scale.) Finally, participants used a 7-point scale to rate how much they enjoyed the music.

Procedure

The procedure was controlled by a computer program created with PsyScope software (Cohen, MacWhinney, Flatt, & Provost, 1993), which presented the music or silence, administered the spatial test, and collected responses. Participants were assigned to one of eight conditions formed in a $2 \times 2 \times 2$ factorial design, with two types of music (Mozart or Albinoni), two testing orders (music-silence or silence-music), and two orders of the PF&C subsets (A-B or B-A).

Participants were tested individually in a sound-attenuating booth. They completed the subjective mood-arousal rating and the POMS and received a demonstration of the PF&C task. They then sat in front of the computer for 10 min wearing headphones. In the silence condition, they sat in silence. In the music condition, they listened to music by Mozart or Albinoni. To encourage participants to attend to the music, we told them that they would be asked questions about it. After the listening-sitting period, participants completed the PF&C task. There was a time limit of 1 min for each of the 17 PF&C trials, with a warning tone presented 5 s before the end of the time limit. Participants then provided an enjoyment rating (music condition only), and again completed the POMS and subjective mood-arousal rating (music and silence conditions). Participants in the music condition were retested 7 days later in the silence condition, and vice versa.

RESULTS

The subset of PF&C items (A or B) had no influence on scores and did not interact with any other variable or combination of variables, and was therefore omitted from further consideration. The primary analysis was a three-way mixed-design analysis of variance (ANOVA), with condition (music or silence), musical excerpt (Mozart or Albinoni), and testing order as independent variables. A significant effect of order was evident, $F(1, 20) = 5.42, p < .05$; participants improved from the first to the second testing session. The strongest effect, however, was the predicted two-way interaction between condition and musical excerpt, $F(1, 20) = 16.89, p < .001$, which is illustrated in Figure 1.

Follow-up analyses were conducted separately for each musical excerpt. For the Mozart group, a two-way (Condition \times Order) ANOVA revealed a significant effect of condition, $F(1, 10) = 22.96, p < .001$. As shown in Figure 1, performance on the PF&C task was significantly better after participants listened to Mozart than after they sat in silence. For the Albinoni group, however, there was no effect of condition.

Analyses of the pretest measures of arousal and mood (obtained before exposure to silence or music) indicated no preexisting differences between conditions. The three posttest measures of arousal and mood (obtained after exposure to silence or music) were examined separately with mixed-design ANOVAs that had one within-subjects variable (music or silence) and one between-subjects variable (Mozart or Albinoni). In each case, the two-way interaction was significant after using the Bonferroni multistage correction for multiple tests (Howell, 1997), $F_s(1, 22) = 8.23, 12.93, \text{ and } 8.49, p_s < .05$, for POMS arousal, POMS mood, and subjective mood-arousal rating, respectively.

To investigate these interactions further, we examined differences between groups (Mozart vs. Albinoni) separately on each measure (correcting for multiple tests; testing order held constant). In the silence condition, there were no differences between the Mozart and Al-

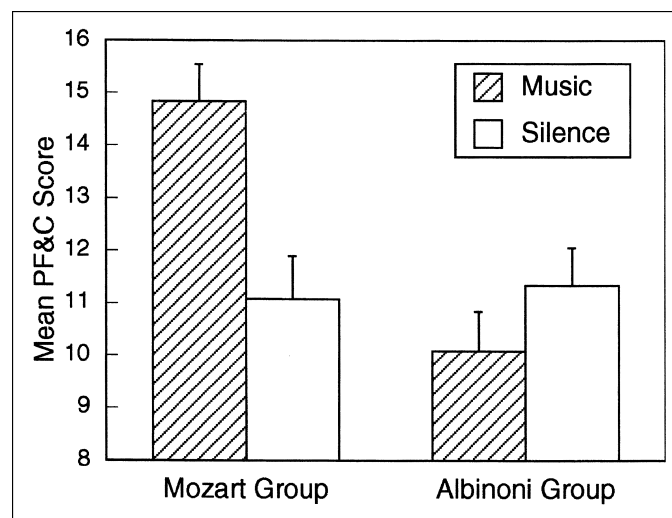


Fig. 1. Participants' mean scores on the paper-folding-and-cutting (PF&C) task after sitting in silence or listening to music. Each participant was tested in a silence condition and a music condition. Half of the participants heard Mozart in the music condition. The other half heard Albinoni. Error bars illustrate standard errors.

Arousal, Mood, and the Mozart Effect

binoni groups on any measure. In the music condition, scores were higher in the Mozart group than in the Albinoni group on the POMS arousal subscale, $F(1, 21) = 9.56, p < .05$, and on the subjective mood-arousal rating, $F(1, 21) = 23.70, p < .001$, but scores in the Mozart group were significantly lower than scores in the Albinoni group on the POMS mood (Depression-Dejection) subscale, $F(1, 21) = 6.20, p < .05$. Enjoyment scores were also higher in the Mozart group, $F(1, 21) = 11.91, p < .01$. Figure 2 illustrates PF&C scores, POMS arousal scores, POMS mood scores (reverse coded), subjective mood-arousal ratings, and enjoyment ratings as a function of musical excerpt (all measures standardized). The figure shows that the different levels of arousal, mood, and enjoyment closely paralleled performance differences on the PF&C task.

Finally, a series of repeated measures analyses of covariance (corrected for multiple tests) tested whether the Mozart effect would remain in evidence when individual differences in enjoyment, arousal, or mood were statistically controlled. For each analysis, the within-subjects variable was testing condition (Mozart or silence), and the covariate represented scores on one of our supplementary measures. Although the Mozart effect remained significant when POMS mood scores were partialled out, $F(1, 10) = 12.93, p < .05$, it was no longer reliable when enjoyment ratings, POMS arousal scores, or subjective mood-arousal ratings were held constant.

DISCUSSION

Participants performed better on a test of spatial abilities after listening to a Mozart sonata than after sitting in silence. When a slow, "sad" musical excerpt by Albinoni was presented instead of a Mozart sonata, there was no effect of exposure to music. Moreover, the two

musical excerpts induced different levels of arousal and mood. Participants who listened to Mozart scored significantly higher on positive mood and arousal (enjoyment rating, mood rating, POMS arousal score) and significantly lower on negative mood (POMS mood score) compared with their counterparts who listened to Albinoni. In short, our findings provide compelling evidence that the "mysterious" Mozart effect (Steele, Bass, & Crook, 1999) can be explained by participants' mood and arousal level.

Our results provide the only direct support for previous suggestions that the short-term effects of listening to Mozart on spatial ability are an artifact of arousal and mood (Chabris, 1999; Nantais & Schellenberg, 1999; Schellenberg, in press). Whereas the findings of Nantais and Schellenberg (1999) demonstrated that the Mozart effect disappears with appropriate experimental controls, the present findings revealed that the effect is also eliminated when enjoyment ratings, POMS arousal scores, or subjective mood-arousal ratings are statistically controlled. The Mozart effect remained significant, however, when POMS mood scores were partialled out. One explanation for this apparent discrepancy is that the POMS mood subscale (Depression-Dejection) measures negative affect, whereas our enjoyment and mood ratings measured positive affect. Positive and negative affect may be relatively independent (Tellegen, Watson, & Clark, 1999). Moreover, they influence cognitive performance in a nonmonotonic manner, and may be mediated by different neural pathways (Ashby et al., 1999). It is possible, then, that the Mozart effect is associated more with positive than with negative mood.

As we noted earlier, a large body of scientific evidence confirms that arousal and mood influence performance on a variety of cognitive tasks. Such effects are evident with moderate changes in arousal or affect, which can be induced with ease. Changes in mood may be in-

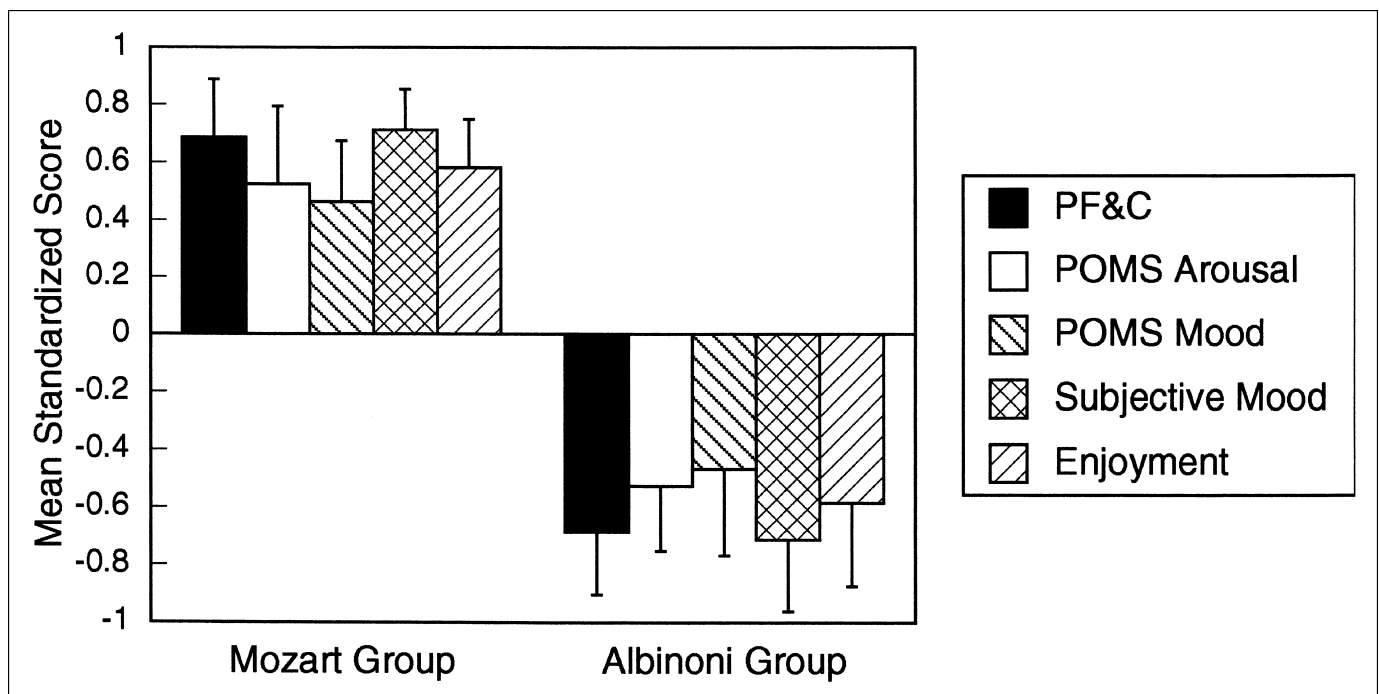


Fig. 2. Participants' mean standardized scores on five measures after listening to Mozart or to Albinoni. Scores are shown for the paper-folding-and-cutting (PF&C) task, Profile of Mood States (POMS) arousal subscale, POMS mood subscale (reverse coded), subjective mood-arousal ratings, and enjoyment ratings. Error bars illustrate standard errors.

duced by giving participants a small gift or showing them a cartoon (Isen, 1999), and changes in arousal occur from moment to moment in response to environmental events (Scheibel, 1980). Music also affects arousal and mood, as evidenced by changes in skin conductance, heart rate, finger pulse amplitude, breathing rate, and other measures (Davis & Thaut, 1989; Krumhansl, 1997), and by listeners' use of music as an agent of emotional change (Sloboda, 1992). In short, our "arousal and mood" explanation of the Mozart effect is entirely consistent with existing evidence.

It is important to note, however, that arousal and positive mood are not identical. Performance on certain tasks, such as creative problem solving, may be facilitated by positive affect but not by arousal. According to Ashby et al. (1999), effects of positive mood are associated with increased levels of dopamine, which project from the ventral tegmental area to several brain areas, including the locus ceruleus. The locus ceruleus, in turn, is the largest producer of norepinephrine, the neurotransmitter most strongly associated with arousal. Thus, although mood and arousal rely on different neurochemical systems, these systems have overlapping neural substrates and may have similar effects on performance in many instances.

In sum, claims that brief exposure to music leads to short-term enhancement of nonmusical skills are misleading. Rather, the Mozart effect can be explained simply: Enjoyable stimuli induce positive affect and heightened levels of arousal, which lead to modest improvements in performance on a variety of tasks.

Acknowledgments—This research was supported by the Natural Sciences and Engineering Research Council of Canada. Doug Gifford and Paul Pilon provided technical assistance. Sandra Trehub provided helpful comments on an earlier version of the manuscript.

REFERENCES

- Albinoni, T.G. (1981). Adagio in G minor for organ and strings [Recorded by I Solisti Veneti, conducted by C. Scimone]. On *Albinoni's adagios* [CD]. Perivale, England: Warner Classics. (1996)
- Ashby, F.G., Isen, A.M., & Turken, A.U. (1999). A neuropsychological theory of positive affect and its influence on cognition. *Psychological Review*, *106*, 529–550.
- Berlyne, D.E. (1967). Arousal and reinforcement. In D. Levine (Ed.), *Nebraska Symposium on Motivation: Vol. 15. Current theory & research in motivation* (pp. 1–110). Lincoln: University of Nebraska Press.
- Chabris, C.F. (1999). Prelude or requiem for the "Mozart Effect"? *Nature*, *400*, 826.
- Cohen, J.D., MacWhinney, B., Flatt, M., & Provost, J. (1993). PsyScope: A new graphic interactive environment for designing psychology experiments. *Behavior Research Methods, Instruments, & Computers*, *25*, 257–271.
- Davis, W.B., & Thaut, M.H. (1989). The influence of preferred relaxing music on measures of state anxiety, relaxation, and physiological responses. *Journal of Music Therapy*, *26*, 168–187.
- Hetland, L. (2000). Listening to music enhances spatial-temporal reasoning: Evidence for the "Mozart effect." *Journal of Aesthetic Education*, *34*, 105–148.
- Holden, C. (1994). Smart music. *Science*, *266*, 968.
- Howell, D.C. (1997). *Statistical methods for psychology* (4th ed.). Belmont, CA: Duxbury.
- Isen, A.M. (1999). Positive affect. In T. Dalgleish & M. Power (Eds.), *The handbook of cognition and emotion* (pp. 521–539). New York: Wiley.
- Koester, L.S., & Farley, F.H. (1982). Psychophysiological characteristics and school performance of children in open and traditional classrooms. *Journal of Educational Psychology*, *74*, 254–263.
- Kovacs, M., & Beck, A.T. (1977). An empirical clinical approach toward a definition of childhood depression. In J.G. Schulterbrandt & A. Raskin (Eds.), *Depression in childhood: Diagnosis, treatment, and conceptual models* (pp. 1–25). New York: Raven Press.
- Krumhansl, C.L. (1997). An exploratory study of musical emotions and psychophysiology. *Canadian Journal of Experimental Psychology*, *51*, 336–352.
- McNair, D.M., Lorr, M., & Droppleman, L.F. (1992). *The Profile of Mood States*. San Diego: Educational and Industrial Testing Service.
- Mozart, W.A. (1985). Sonata for two pianos in D major, K 448 (K. 3375a) [Recorded by M. Perahia & R. Lupu]. On *Music for piano, four hands* [CD]. London: Sony Classical. (1992)
- Nantais, K.M., & Schellenberg, E.G. (1999). The Mozart effect: An artifact of preference. *Psychological Science*, *10*, 370–373.
- NBC News (Producer). (1994, September 1). *Dateline NBC*. Livingston, NJ: Burrelle's Information Services.
- O'Hanlon, J.F. (1981). Boredom: Practical consequences and a theory. *Acta Psychologica*, *49*, 53–82.
- Rauscher, F.H., Shaw, G.L., & Ky, K.N. (1993). Music and spatial task performance. *Nature*, *365*, 611.
- Rauscher, F.H., Shaw, G.L., & Ky, K.N. (1995). Listening to Mozart enhances spatial-temporal reasoning: Towards a neurophysiological basis. *Neuroscience Letters*, *185*, 44–47.
- Sarason, I.G. (1980). *Test anxiety: Theory, research, and applications*. Hillsdale, NJ: Erlbaum.
- Scheibel, A.B. (1980). Anatomical and physiological substrates of arousal: A view from the bridge. In J.A. Hobson & M.A.B. Brazier (Eds.), *The reticular formation revisited: Specifying function for a nonspecific system* (pp. 55–66). New York: Raven Press.
- Schellenberg, E.G. (in press). Music and non-musical abilities. *Annals of the New York Academy of Sciences*.
- Sloboda, J.A. (1992). Empirical studies of emotional response to music. In M.R. Jones & S. Holleran (Eds.), *Cognitive bases of musical communication* (pp. 33–46). Washington, DC: American Psychological Association.
- Solomon, R.L., & Corbit, J.D. (1974). An opponent-process theory of motivation. *Psychological Review*, *81*, 119–145.
- Steele, K.M., Bass, K.E., & Crook, M.D. (1999). The mystery of the Mozart effect: Failure to replicate. *Psychological Science*, *10*, 366–369.
- Steele, K.M., Dalla Bella, S., Peretz, I., Dunlop, T., Dawe, L.A., Humphrey, G.K., Shannon, R.A., Kirby, J.L., Jr., & Olmstead, C.G. (1999). Prelude or requiem for the "Mozart Effect"? *Nature*, *400*, 827.
- Tellegen, A., Watson, D., & Clark, L.A. (1999). On the dimensional and hierarchical structure of affect. *Psychological Science*, *10*, 297–303.
- Yerkes, R.M., & Dodson, J.D. (1908). The relationship of strength of stimuli to rapidity of habit formation. *Journal of Comparative and Neurological Psychology*, *18*, 459–482.

(RECEIVED 6/15/00; ACCEPTED 8/11/00)