Journal of Articles in Support of the Null Hypothesis
Vol. 10, No. 1
 1539-8714
www.jasnh.com

No Effect of a Brief Music Intervention on Test Anxiety and Exam Scores in College Undergraduates

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This study examined classical music's effect on test anxiety and exam performance in a college setting by randomizing students to (1) listen to Mozart while studying and taking an exam, (2) study and take the exam under usual conditions, or (3) choose between these two alternatives. We controlled for: prior exam performance, year in college, age, the amount of time ordinarily listening to classical music and music while studying, and condition preference. There was no effect on either outcome. Students were positively disposed toward the intervention, but did not typically listen to classical music or to music while studying. Although this intervention did not decrease test anxiety or enhance exam performance, more extensive or tailored music interventions could hold promise.

Key Words: test anxiety, exam performance, music, intervention, Mozart

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"Math exams terrify me. My palms get sweaty, I breathe too fast, and often I can't even make my eyes focus on the paper. It's worse if I look around, because I'd see everybody else working, and know that I'm the only one who can't do it" (Woods, n.d.). This quote from a college student illustrates how debilitating test anxiety can be. Students with test anxiety typically experience worry about the exam result, tension or jitteriness, irrelevant thoughts, and bodily reactions like stomachaches or headaches (Sarason, 1984). Test anxiety plays a significant role in academic settings and may prevent some students from realizing their fullest academic potential (Betz, 1978; Chapell et al., 2005; McDonald, 2001; Powell, 2004a, 2004b; Seipp, 1991). Studies have suggested that both state and trait anxiety negatively influence exam performance and that individual characteristics, such as levels of self-efficacy and the perceived ability to work under pressure, significantly influence test anxiety (Cassady & Johnson, 2002; Chapell et al., 2005; Kahan, 2009; Munz, Costello, & Korabik, 1975; Onyeizugbo, 2010). However, there appear to be few differences in test anxiety between males and females (Onyeizugbo, 2010; Seipp, 1991).

Potential methods to alleviate test anxiety include systematic desensitization, vicarious desensitization, progressive muscle relaxation, positive self-instruction, imagination techniques, attention training, cognitive restructuring, study skills training, and alternative therapies such as hypnosis (Altmaier & Woodward, 1981; Arnkoff, 1986; Deffenbacher & Michaels, 1981; Dendato & Diener, 1986; Harris & Johnson, 1980; Melnick & Russell, 1976; Ribordy, Tracy, & Bernotas, 1981; Wachelka & Katz, 1999; Wise & Haynes, 1983). Of these, only systematic desensitization, vicarious desensitization, positive self-instruction, imagination techniques, attention training, and cognitive restructuring have reliable evidence for their efficacy (Neuderth, Jabs, & Schmidtke, 2009). However, study skills training, when used in combination with other methods such as systematic desensitization, has been found to bolster the anxiety-reducing effects of these other methods (Neuderth et al., 2009).

A small literature suggests that music is an effective means to reduce test anxiety. For instance, two studies found a reduction in test anxiety with high school students and college students studying with background music for 10 minutes before an exam (Haynes, 2004; Sezer, 2009). This effect is further supported by findings that music reduces anxiety in medical populations (Bradt & Dileo, 2009; Evans, 2002; Pelletier, 2004) with an average effect size of $d = .60$, occupational stress with an effect size of $d = .48$ (Pelletier, 2004), and artificially-induced anxiety in university laboratory settings with an effect size of $d = .73$ (Pelletier, 2004). Additionally, music may refocus attention away from more aversive physiological stimuli and play a role in arousal control (Barwood, Weston, Thelwell, & Page, 2009; Priest & Karageorghis, 2008). These influences may also reduce test anxiety in academic testing situations (Bar-Haim, Morag, & Glickman, 2011; Little & Jackson, 1974; Onyeizugbo, 2010; Ribordy et al., 1981; Sud, 1994; Wise & Haynes, 1983).

Music may also have the added benefit of improving mental functioning, although the evidence is mixed. Rauscher, Shaw, and Ky (1993) first reported that students who listened to ten minutes of Mozart's Sonata for Two Pianos in D Major K. 488 had a short lived eight-point IQ score increase in spatial-temporal intelligence, a finding that was termed the "Mozart Effect." Some studies failed to replicate this finding (Chabris, 1999; McKelvie & Low, 2002; Standing, Verpaelst, & Ulmer, 2008; Steele, Dalla Bella, et al., 1999), whereas others replicated it, but suggested that music's effects may actually have more to do with the arousal or enjoyment associated with it (Caldwell & Riby, 2007; Cassity, Henley, & Markley, 2007; Roth & Smith, 2008; Thompson, Schellenberg, & Husain, 2001;

Wichian, 2010). Still other studies have pointed to a unique association between music by Mozart relative to other classical composers and brain activity (Hughes, 2001, 2002), and to reductions of seizures (Lahiri & Duncan, 2007). A meta-analysis concluded that listening to Mozart, compared to a non-musical stimulus or no music at all may have only a small effect on measures of intelligence (Pietschnig, Voracek, & Formann, 2010).

Music may have an indirect effect on test anxiety and performance by altering mood. Music can influence mood through its effect on dopamine in the reward system of the brain. Specifically, music activates areas in the ventral striatum, the ventral tegmental area, and the hypothalamus (Koelsch, 2010). Music activates the nucleus accumbens when a person enjoys a particular moment in music and the caudate when a person anticipates the approach of an enjoyable portion of music (Koelsch, 2010; Salimpoor, Benovoy, Larcher, Dagher, & Zatorre, 2011). Mood can play an essential role during exams because when positive mood is induced students may worry less, feel more capable of coping with the exam, and perform better (Nelson & Knight, 2010). Positive mood also may make it easier for students to reach a state of flow, or energized focus and full involvement (Csikszentmihalyi, 1975; Csikszentmihalyi & Rathunde, 1993), when taking their exams. Classical music, especially the music of Mozart, has been shown to foster this type of mood (Steele, Bass, & Crook, 1999; Thompson et al., 2001).

However, this influence of music is likely moderated by a student's preferences; for instance, listening to music when taking an exam may be distracting or may not reduce anxiety if students do not wish to listen to music or do not enjoy it. This idea is supported by a study that compared listening to Mozart's music to the default soundtrack (heavy metal) on subjects' scores on Tony Hawk's Pro Skater 3, a computer game that taps spatially-related skills (Cassity et al., 2007). The investigators reasoned that, if arousal rather than a specific effect of Mozart's music was operating, then any music that participants enjoyed would be related to better performance. Overall, listening to music from a genre that participants indicated they liked resulted in higher scores.

Not only may students' musical preferences play a role in a music intervention's effectiveness, but so can having the ability to choose their intervention condition in a treatment trial. Studies based in self-determination theory, that emphasizes autonomy, competence, and relatedness (Ryan & Deci, 2000) have suggested, for example, that choice can be motivating for students when the options are simple, relevant to their goals, and consistent with their cultural values (Katz & Assor, 2007). Additionally, having choice, rather than being assigned to an intervention condition, can influence participants' overall attendance, motivation to complete an intervention, and intervention outcomes in a positive manner (Birdsell, Ream, Seyller, & Zobott, 2009; Ciani, Summers, Easter, & Sheldon, 2008; Janevic et al., 2003; Shadish, Clark, & Steiner, 2008). This suggests that having a choice of the intervention condition to which they are exposed to, over and above the effects of the intervention itself, may increase students' effort, thereby increasing their overall success on a performance task.

Thus, music may have potential as an intervention to reduce test anxiety and increase exam performance for college students. As opposed to other types of interventions to alleviate test anxiety, which may require professionally-trained personnel, individual sessions outside of the classroom, or equipment such as videotapes (Altmaier & Woodward, 1981; Cheek, Bradley, Reynolds, & Coy, 2002; Deffenbacher & Michaels, 1981; Melnick & Russell, 1976; Miller, Morton, Driscoll, & Davis, 2006; Yahav & Cohen, 2008), allowing students to listen to music while studying for and taking an exam is easily administered,

inexpensive, and may be appealing and enjoyable. However, only a limited number of studies have investigated how music might improve test anxiety, and these did not take into account students' musical preferences, nor did they capitalize on providing students with some choice (Haynes, 2004; Sezer, 2009). This is an important consideration because, if educators are going to use music interventions in the classroom, such preferences may be very important and might even result in worse outcomes. This study addresses how acceptable and effective a classical music intervention involving pieces by Mozart is for college students and adds to the research on interventions to alleviate test anxiety. Furthermore, this study provides information on whether allowing students to choose to be exposed to a musical intervention or not, a circumstance that might be necessary in practice, enhances its effects.

We have previously reported results from a study that examined the implementation of this music intervention in college undergraduates (Floyd & Moyer, 2010). The focus of that study was to investigate the effects of randomization procedures on participants' feelings about the research study and their participation experience. The present report makes use of this same data to make a preliminary examination of the potential benefits of musical interventions in the college classroom by examining the effects of listening to Mozart's music on test anxiety and exam performance. The study involved two arms, each with a Music Listening condition and a normal, silent Control condition. One arm, the Randomized Control Trial (RCT) arm, provided an efficacy test of listening to the music of Mozart by randomly assigning students to the two conditions. The other arm, the Preference Control Trial (PCT) or Choice arm, provided a more ecologically valid test of how the intervention might be used under real-world conditions by allowing students to choose which of the two conditions they wanted. We included several relevant covariates that might be related to exam performance and test anxiety and on which students scores might vary across groups when they chose their treatment condition: students' performance on prior course exams, year in college, age, the amount of time they typically listened to music when studying, how often they listened to classical music generally, and the strength of the students' condition preference. We recorded whether or not the students attended any of the optional study sessions and the amount of time they spent at the study sessions. In light of past research and theory, we hypothesized that:

1. Students randomly assigned to receive a brief music intervention involving being exposed to the music of Mozart while studying for and while writing a college exam would have lower test anxiety and higher exam scores compared to students exposed to a condition that involved silent studying and usual silent testing conditions.
2. Students who choose to receive the brief music intervention would have lower test anxiety and higher exam scores than those who chose to receive the silent studying and usual silent testing conditions.

Method

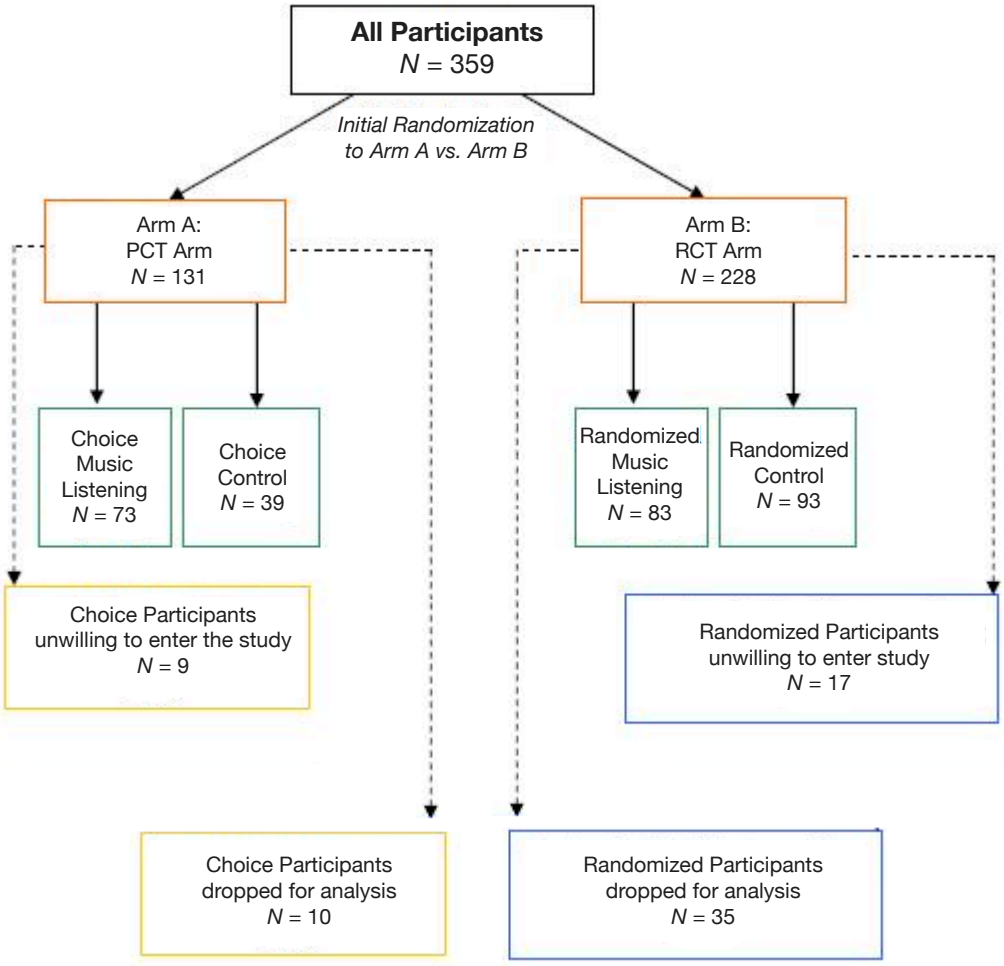
Participants

Participants were undergraduate psychology students enrolled in either Introduction to Psychology or Research Methods, as reported elsewhere (Floyd & Moyer, 2010). They were recruited from the Psychology Department subject pool and earned course credit for their participation. We obtained IRB approval to conduct the study.

Design and Procedures

The study was a two-armed design whereby subjects were first randomly assigned to either the randomized arm or the choice arm. The participants were assigned to the two arms in a 2:1 ratio, in an effort to balance the size of the groups receiving the intervention, in anticipation that in the choice arm the intervention would be chosen more often. The subjects in the randomized arm were randomly assigned to either the Music Listening condition or to the Control condition. The subjects in the choice arm were permitted to choose their condition (Wennberg, Barry, Fowler, & Mulley, 1993; Figure 1). Students were free to withdraw at any point, if they had second thoughts about taking course examinations that contributed to their college grades under the conditions that were part of the study. In accordance with the ethical guidelines specified by our institutional IRB, participants were given partial credit for completing the baseline questionnaires, even if they did not wish to continue further in the study.

Figure 1: *Flow Chart for Participants.*



The Music Listening condition involved students listening to Mozart both during scheduled, but optional, self-study sessions for their second in-class multiple-choice exam for the course (exam two) and while taking this exam. The study sessions were made optional to mirror the way in which a music intervention for college students might be administered in practice. Sonatas composed by Mozart in addition to Mozart's Sonata for Two Pianos in D Major K. 448, the piece for which Rauscher et al. (1993) had first documented an effect on IQ, were played just loud enough for everyone in the room to hear. This prevented participants in the treatment condition from habituating to one song or becoming annoyed by listening to the same song for the duration of their exam. The Control condition involved similar, but silent, scheduled and optional self-study sessions and normal silent testing conditions. Because the multiple-choice exams for both conditions were held simultaneously, the students in the Music Listening condition wrote their exams in rooms other than the regular lecture hall whereas students in the Control conditions wrote in the regular lecture hall. One to two weeks prior to the first in-class course examination, a member of the research team presented the study to each class and invited students to participate. The potential participants were informed about the Mozart Effect to encourage them to participate in the study, but for ethical reasons, similar to the imperative for clinical equipoise emphasized in clinical trials, they were also informed about the mixed results and lack of evidence for effects in college students writing course exams.

Measures

We collected the following demographic variables at baseline: year in college, age, gender, race, and self-reported grade point average (GPA). We measured the participants' preference for the Music Listening versus the Control condition using a four- point Likert scale (1 indicating *strongly prefer normal testing* and 4 indicating *strongly prefer musical testing*). Then we recoded this to represent the strength of participants' preference as either strongly or somewhat preferring either condition. We queried how familiar students were with classical music by asking on a 4-point scale how often they listened to classical music generally (1 indicating never and 4 indicating *several times a week*). We also assessed the percentage of time students listened to music while studying with an 11-point scale (1 indicating that the students never listened to music when studying for an exam [0%] and 11 indicating that students listened to music all the time when studying for an exam [100%]). Additionally, we assessed participation in the study sessions by recording attendance at and minutes spent in the sessions. Exams were the multiple-choice tests typically administered in the courses, consisting of items that assessed both understanding of definitions of terms and applications of content. We measured state test anxiety shortly following the second exam (within 5 days) with an 8-item modified version of the Spielberger Test Anxiety Inventory (Spielberger, 1980) developed by Hong (1998) that adjusted the verb tense of the items to refer to specific testing situations rather than testing situations in general. This measure had good internal consistency in our sample (Cronbach's $\alpha = .88$).

Data Preparation and Plan of Analyses

Missing values for both exam one and exam two were predicted from the other exam score due to the high correlation between the two exam scores and imputed. Missing values for total state test anxiety were imputed from the mean of this measure's subcomponents.

All students with missing values on any other variables were dropped from the analyses. We conducted a power analysis incorporating the results of one prior meta-analysis for the average effect size of Mozart's music on measures of intelligence from a recent meta-analysis, $d = .37$ (Pietschnig et al., 2010), and the average of three past studies for the effect size of music on reducing arousal, $d = .60$ (Bradt & Dileo, 2009; Evans, 2002; Pelletier, 2004). This indicated that to detect an effect on the two dependent variables at .8 power, we needed at least 34 participants in one group and 68 participants in the other for test anxiety, and 87 participants in one group and 173 participants in the other for exam grades. Thus, the study was adequately powered to detect an effect on test anxiety but potentially underpowered to detect an effect on exam scores.

We report the results of the two arms of the trial, the Randomized and the Choice Arm, separately. First, we tested whether the Music Listening and Control conditions were balanced with respect to demographic and background variables at baseline. We ran two ANCOVAs for each arm using test anxiety and scores on exam two as dependent variables; the covariates included variables on which students varied upon that were anticipated to be related to their performance on exam two: students' performance on prior course exams, year in college, age, the amount of time students listened to music when studying, how often they listened to classical music generally, and the strength of the students' condition preference.

Results

Randomized Control Trial (RCT) Arm

We analyzed 176 students in the Randomized Arm of the Study, with 83 students in the Music Listening condition and 93 students in the Control condition. The sample was 66.5% female, 33.5% male, 50.6% White or Caucasian, 27.3% Asian, 13.6% Other, 5.7% Black or African American, and 2.3% Native Hawaiian or other Pacific Islander. The mean age was 20.34 ($SD = 3.63$), and the students were 30.1% freshmen, 20.5% sophomores, 28.4% juniors, and 21.0% seniors and above. The students' mean reported GPA was 3.23 ($SD = .53$) and their mean score out of 100 points on the first exam for the course was 80.88 ($SD = 12.16$). The largest percentage, 34.1% of students, reported that they listened to classical music only once or twice a year, and indicated that the percentage of time they spent listening to any music while studying was 30%. Regarding preference for condition, more students in the Randomized arm "somewhat preferred" their preferred condition (57.4%), than "strongly preferred" their preferred condition (42.6%), indicating that students were not too overly invested in whether or not they were assigned to their preferred condition. Students did prefer the music condition to the Control condition at a rate of 3:2, however, with 105 students preferring the Music Listening condition, and 71 students preferring the Control condition.

We compared the Music Listening and Control groups at baseline on gender, age, year in college, GPA, scores on the first course exam, frequency of listening to classical music, percent of time studying spent listening to music and the strength of their preference. Only percentage of time spent studying while listening to music was significantly different, $t(174) = 2.53$, $p = .01$, $d = .39$, with the Control group doing this less frequently, about 20% of the time, than the Music Listening group, who did this about 40% of the time. Thirty-six percent of students in the Music Listening condition and 28% in the Control

condition attended a study session; these proportions were not significantly different, χ^2 (1, N = 176) = 1.36, p = .24. Of the students who attended a study session, the average number of minutes spent by those in the Music Listening condition, M = 80.67, SD = 31.93, was not significantly different from that spent by those in the Control condition, M = 67.77, SD = 38.32, t(54) = -1.37, p = .18, d = .37. Although exam scores were not different across conditions, as is common for upper- versus lower-level courses, those obtained in the Research Methods courses were higher than those for Introductory Psychology Courses, t(174) = 6.95, p < .001, d = 1.00.

Prior to conducting the ANCOVA, we examined the assumption of homogeneity of regression by testing the interaction of the two conditions (Music Listening and Control) with each covariate. These interactions were not significant, indicating that it was appropriate to use these covariates. The ANCOVA, including students' performance on prior course exams, year in college, age, the amount of time they typically listened to music when studying, how often they listened to classical music generally, and the strength of the students' condition preference as covariates, indicated that there were no significant group differences in the mean levels of test anxiety experienced by the Music Listening group, M (adjusted) = 15.25, SE = .53, 95% CI [14.22, 16.29], and the Control group, M (adjusted) = 15.72, SE = .50, 95% CI [14.74, 16.70], Levene's test of equality of variances, F(1, 174) = 1.90, p = .17, F (1,168) = .42, p = .52, η_p^2 < .01.[1] Similarly, there were no significant group differences in the mean scores on the second course exam, M (adjusted) = 78.33, SE = 1.11, 95% CI [76.14, 80.52], and M = 79.21 (adjusted), SE = 1.05, 95% CI [77.15, 81.28] Levene's test of equality of variances, F(1, 174) = .99, p = .32, respectively, including these same variables and test anxiety as covariates, F (1,167) = .33, p = .57, η_p^2 < .01.[2] We repeated our analyses without imputations and using only pairwise deletion for missing variables, and without covariates, and the pattern of results did not differ from what is reported above.

Preference Control Trial (PCT) Choice Arm

We analyzed 112 students in the Choice Arm of the Study with 73 in the Music Listening condition and 39 in the Control condition. This indicated that the students chose the Music Listening option in a significantly different 2:1 ratio χ^2 = 10.32 p < .001. The sample was 58.0% female, 42.0% male, 47.3% White or Caucasian, 34.8% Asian, 13.4% Other, and 3.6% Black or African American. The mean age was 20.19 (SD = 3.37), and they were 33.0% freshmen, 17.9% sophomores, 29.5% juniors, and 19.7% seniors and above. The students' mean reported GPA was 3.26 (SD = .49) and their mean score out of 100 points on the first exam for the course was 79.51 (SD = 11.34). The largest percentage, 35.7%, reported that they listened to classical music once or twice a year and indicated that the average percentage of time that they spent listening to music while studying was 30%. Overall, a greater percentage of the students in the Choice Arm only "somewhat preferred" their preferred condition, 58.9%, than "strongly preferred" their preferred

1 An ANCOVA including only those students who attended the study sessions produced similar results F(1,48) = .80, p = .37, η_p^2 < .02.

2 An ANCOVA including only those students who attended the study sessions produced similar results F(1,47) = .15, p = .70, η_p^2 < .01.

condition, 41.1%, indicating that overall students were not too invested in whether or not they had received their preferred condition.

We compared the Music Listening and Control groups at baseline on gender, age, year in college, GPA, scores on the first course exam, frequency of listening to classical music, percent of time studying spent listening to music, and the strength of their preference. There were significant differences between the groups for grade on exam one, $t(110) = 2.42$, $p < .05$, $d = .48$, with those who chose the Control condition having higher scores, $M = 82.99$, $SD = 12.00$, than those who choose the Music Listening condition, $M = 77.66$, $SD = 10.59$. Additionally, there were significant differences between the groups on how often students reported that they listened to classical music generally (with the largest percentage of the Music Listening group reporting once or twice a year versus the modal percentage of the Control group reporting never) and the percentage of time students listened to music while studying (with the Music Listening group reporting doing this about 40% of the time versus the Control group reporting doing this about 20% of the time), $t(110) = -3.25$, $p < .01$, $d = .64$, and $t(110) = -3.27$, $p < .01$, $d = .61$, respectively. There was also a significant difference in the groups on their strength of preference, χ^2 $(1, N = 112) = 4.09$, $p < .05$, with more students who chose the Music Listening group reporting a strong preference for their condition. Forty percent of students in the Music Listening condition and 31% in the Control condition attended a study session; these proportions were not significantly different, χ^2 $(1, N = 112) = .88$, $p = .35$. Of the students who attended a study session, the average number of minutes spent by those in the Music Listening condition, $M = 87.69$, $SD = 33.24$, approached a significant difference from that spent by those in the Control condition, $M = 68.00$, $SD = 32.69$, $t(39) = -1.73$, $p = .09$, $d = .60$. Although exam scores were not different across conditions, as is common for upper- versus lower-level courses, those obtained in the Research Methods courses were higher than those for Introductory Psychology Courses, $t(110) = 5.09$, $p < .001$, $d = .96$.

Prior to conducting the ANCOVA, we examined the assumption of homogeneity of regression by testing the interaction of the two conditions (Music Listening and Control) with each covariate. These interactions were not significant, indicating that it was appropriate to use these covariates. The ANCOVA, with students' performance on prior course exams, year in college, age, the amount of time they typically listened to music when studying, how often they listened to classical music generally, and the strength of the students' condition preference included as covariates, suggested that there were no significant group differences in the mean levels of test anxiety experienced by the Music Listening group, M (adjusted) = 14.78, $SE = .58$, 95% CI [13.64, 15.92], and the Control group, M (adjusted) = 13.75, $SE = .82$, 95% CI [12.14, 15.37], $F(1,104) = .96$, $p = .33$, $\eta_p^2 = .01$, Levene's test of equality of variances, $F(1, 110) = .59$, $p = .45$.[3] Similarly, there were no significant group differences in the mean scores on the second course exam for the Music Listening, M (adjusted) = 77.68, $SE = 1.08$, 95% CI [75.54 79.82], and the Control group, M (adjusted) = 78.92, $SE = 1.53$, 95% CI [75.89, 81.95], Levene's test of equality of variances, $F(1, 110) = 1.33$, $p = .25$, including these same variables and test

3 An ANCOVA including only those students who attended the study sessions produced similar results $F(1,33) = .07, p = .79, \eta_p^2 < .01$

anxiety as covariates, $F(1,103) = .40$, $p = .53$, $\eta_p^2 < .01$.[4] We repeated our analyses without imputations and using only pairwise deletion for missing variables, and without covariates, and the pattern of results did not differ from what is reported above.

Discussion

The goal of our study was to make a preliminary attempt at identifying the potential benefits of a musical intervention in the college classroom by examining the effects of listening to Mozart's music on test anxiety and exam performance. We predicted that music would have beneficial effects on these outcomes and that these effects might be enhanced for students who were allowed to choose their studying and testing conditions. The data did not support these hypotheses. However, we did not find evidence that using Music Listening as an intervention in educational settings was unacceptable to students. In fact, we found that a majority of students preferred the musical intervention to normal testing, either when they were allowed to choose their condition, or when they were randomly assigned to a condition but made ratings about their preference. We also found that in the choice condition, those who chose the music intervention had lower exam one scores.

These findings differ from past research that showed an effect for music on test anxiety (Haynes, 2004; Sezer, 2009) but are in line other studies suggesting that music has no effect on measures of academic performance or intelligence (Chabris, 1999; Haynes, 2004; McKelvie & Low, 2002; Standing et al., 2008; Steele, Dalla Bella, et al., 1999). This failure to support our hypotheses should be viewed in terms of the specific methodological details and limitations of the study before concluding that that music has no potential use in alleviating test anxiety or improving exam performance. For instance, in our study, few students attended the optional study sessions. Although making the study sessions optional was intended to mirror how such an intervention might be delivered in practice, this could have weakened any effects in the music conditions if there were any (although analyses including only students who attended the sessions did not find significant group differences). For instance, this lack of engagement not only lowered the overall exposure to the purported active ingredient of the music intervention, it also limited the opportunity for students to encode exam material under the same auditory conditions as they took the exam, and thus capitalize on well-documented state-dependent learning effects (Bower, 1981; Miles & Hardman, 1998; Ucros, 1989). Additionally, the low rates of listening to music while studying indicates that the music condition involved a somewhat unfamiliar activity for our sample. Those who chose the Music Listening condition were significantly more likely to report that they listened to classical music generally and listened to music while studying, but even the levels for these students were still fairly low. This may have limited any effect of music because, although students tended to prefer the music condition, their lack of familiarity with listening to background music during studying or an exam may have led to distraction. Including measures of level of distraction in future research

4 An ANCOVA including only those students who attended the study sessions produced similar results $F(1,32) = .36$, $p = .55$, $\eta_p^2 = .01$. Finally, both study arms were combined and run as a 2x2 ANCOVA with condition (Music Listening and Control) and study arm (PCT and RCT) as between subject factors. Despite the larger power, there were no main effects for condition $F(1,187) = 1.24$, $p = .27$, $\eta_p^2 < .01$. Additionally, there were no main effects for study arm $F(1,187) = .01$, $p = .92$, $\eta_p^2 < .001$ or the interaction between condition and study arm $F(1,187) = .39$, $p = .53$, $\eta_p^2 < .01$.

would help illuminate this issue.

Limitations of our study also include the assessment of test anxiety only after the exam, rather than during or before the exam. This makes it possible that a student's recall of their exam anxiety was biased by their emotions after taking the exam, which may be related to how they felt they did on the exam, and therefore was not an accurate portrayal (Levine, 1997). In addition, levels of test anxiety were fairly low, ranging from 13.75-15.72 out of a maximum score of 32, indicating that, on average, students rated their responses to the test anxiety items to be "somewhat" true for them. It is possible that music or any other intervention addressing test anxiety would be most effective for those with elevated levels to begin with. Furthermore, because levels of test anxiety were not assessed at baseline, particularly for the choice arm, we are unclear to what extent the treatment groups may have been unbalanced on this variable, muddying the interpretation of results. Unlike past studies, we also did not measure associated mood or physiological arousal levels (Oetting, 1966; Spangler, Pekrun, Kramer, & Hofmann, 2002). Other factors such as sleep disruption, caffeine intake were not measured and might also have contributed to variations in response (Babson, Trainor, Feldner, & Blumenthal, 2010; Daniela et al., 2010; Lieberman, Tharion, Shukitt-Hale, Speckman, & Tulley, 2002; Selvi, Gulec, Agargun, & Besiroglu, 2007). Finally, space considerations necessitated students in the Control condition taking their exam in the usual lecture hall, while the students in the Music Listening condition took their exam in a different room. This created a confound, such that students in the Control condition had the benefit of being in a familiar room where they had been taught the material that was being tested on the exam, whereas the students in the Music Listening condition did not. This potentially allowed the students in the Control condition to capitalize on well-documented environment dependent learning effects (Russo, Ward, Geurts, & Scheres, 1999; Weir & May, 1988). However, research suggests that these effects are most likely for students who have not studied adequately. These students may find the test material unfamiliar, forcing them to rely more on environmental cues to remember the material than on the recognition cues inherent in multiple-choice exams (Russo et al., 1999).

Future research also could expand on our study design to include relevant physiological variables related to test anxiety. Prior studies have examined heart rate, finger temperature, blood pressure, cortisol levels, and GABA levels in stress reduction using standard distress-reducing music that involves a slower tempo, low pitches, string instruments, regular rhythms, no extreme dynamics, and no lyrics (Han et al., 2010; Lai et al., 2008; Pelletier, 2004). Additionally, future research should measure a student's pre-intervention anxiety before taking the exam, or perhaps as, mentioned above, target those with especially high-test anxiety. In support of this, prior studies have shown that levels of pre-intervention distress significantly moderate an intervention's effect (Schneider et al., 2010). In addition, future research should identify the particular qualities of music, beyond the particular type or composer, that may be effective for students in an academic setting. For instance, there is some evidence that change in musical tempo leads to increased work in an exercise setting (Szabo, Small, & Leigh, 1999), that people recover better from exercise with slow music (Savitha, Mallikarjuna, & Rao, 2010) and that slow music is often used to reduce anxiety (Pelletier, 2004).

Future research also needs to control for levels of background noise, levels of extroversion, and the possible non-independence of data due to students taking their exam together in a classroom versus taking the exam individually. Specifically, background noise caused by instructors answering student's questions, students dropping pencils, and

instructors giving directions to the entire class can affect a student's performance (Banbury & Berry, 1998) particularly if the student is introverted (Furnham & Strbac, 2002). Depending on what classroom a student takes their exam in, this effect of background noise can be different between testing environments. Music may have its effect by drowning out some of this interference; however, this noise abatement does not always occur (Schlittmeier & Hellbrück, 2009). Finally, future research should look at the effect of pre-intervention functioning on participation and drop out in intervention studies. Our study found that in the choice arm those who chose the musical intervention had done worse on their first exam. This indicated perhaps that those with lower grades were more motivated to try a novel and potentially helpful testing condition. We may expect this pattern to hold true in college populations; however, this pattern may reverse in other populations, such as those who are severely medically impaired, due to their greater symptom severity.

Although the effect sizes found in the current study were quite small, it may be possible, with a stronger music intervention that involves more exposure to music during studying and exams, to find beneficial effects of music on test anxiety and exam performance. Future musical interventions also might involve allowing students to develop their own playlists that reflect their own musical preferences. Because students would likely resonate with music they enjoy more than music assigned to them, this could maximize student engagement with the intervention. Allowing each individual student to bring a player with preferred music to class would allow all students to take the exam in the same room, but would necessitate procedures to prevent using the devices to cheat. Ultimately, if future studies find a link between Music Listening and exam performance, then music could be used independently or in combination with other interventions in order to help students realize their fullest academic potential. This will help students with debilitating test anxiety breathe a sigh of relief.

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Received: 2.17.2013
Revised: 4.12.2013
Accepted: 4.13.2013