1997

Reassessing the Mozart Effect: Musicians and Non-Musicians Respond Differently to Late Eighteenth-Century, Non-Texted Music for a Monochromatic Instrument

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Abstract

Recent accumulating evidence suggests a relationship between music and spatial-reasoning. One particular link, the termed "Mozart effect," is an enhancement in performance on spatial-reasoning tasks after listening to the first movement of a sonata by Mozart. Though some studies offer additional evidence to support the "Mozart effect," it is interesting that a number of studies attempting to reproduce it have failed. Accordingly, this study investigated the "Mozart effect" using an alternative means of assessing spatial-reasoning ability. Additionally, the music of Haydn was used in an effort to reproduce the effect. Lastly, a differentiation was made between the scores of musicians and non-musicians. No significant differences were found in scores among conditions of Mozart, Silence, or Haydn. However, a marginally significant interaction was found between musician groups and stimulus groups. Additionally, when lumped together, musicians scored higher after listening to music and non-musicians scored higher after listening to silence. The trends found in this study offer an explanation for why previous research has failed to find an enhancement, as the differences in scores between musicians and non-musicians apparently cancel out when the two groups are combined .

Reassessing the Mozart Effect: Musicians and Non-Musicians Respond Differently to Music

In 1993, Frances Rauscher, Gordon Shaw, and Katherine Ky reported a finding that, compared to a guided imagery relaxation tape or silence, listening to 10 minutes of Mozart's piano sonata for two pianos in D major, K.448, significantly enhanced a person's performance on abstract reasoning tests taken from the Stanford-Binet Intelligence Exam (Rauscher, Shaw and Ky 1993). The enhancing effect was found to be temporal, not extending beyond 10-15 minutes. Further, it was predicted that "music lacking complexity or which is repetitive would interfere with rather than enhance, abstract reasoning" (Rauscher 1993). Additionally, it was suggested that future research explore differences between musicians and non-musicians.

In 1995, a follow-up study, conducted by the same group of researchers, replicated the finding that listening to the above described Mozart sonata affected spatial-temporal reasoning, a phenomenon which was subsequently termed the "Mozart effect" (Rauscher, Shaw, Levine, Ky, and Wright 1995). It was also found that neither "repetitive" music, that of minimalist composer Phillip Glass, nor a taped short story was successful in producing the "Mozart effect." Additionally, it was found that short-term memory was not enhanced by any of the listening conditions. Further, in light of predictions from a structural neural model of the brain (Leng, Shaw, and Wright 1990), a proposal for establishing a neurophysiological basis for the "Mozart effect" offered that "music acts as 'exercise' for exciting and priming the common repertoire and sequential flow of the cortical firing patterns responsible for higher brain functions"[1] and that "the symmetry operations among the

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[1]Cognitively speaking, in this context, the use of the word *priming* is understood to indicate that, in effect, an exterior stimulus may act as an assimilated, unknown natural mechanism responsible for the progressive enhancement of performance due to repeated exposure, or practice.

inherent patterns [of a structured cortical model of the brain] are enhanced and facilitated by music." Predictions from this study led to a longitudinal study which found that, compared to "singing," "computer," or "no lessons" groups, pre-school children who received piano keyboard lessons subsequently performed significantly higher on tests designed to measure spatial-temporal reasoning. These findings, in conjunction with the results from an electroencephalograph (EEG) study (Sarnthein, vonStein, Rappelsberger, Petsche, Rauscher, Shaw, in press), suggested that "music training, unlike listening, produces long-term modifications in underlying neural circuitry in regions [of the brain] not primarily concerned with music" (Rauscher, Shaw, Levine, Wright, Dennis, and Newcomb, in press).[2] Further, the EEG study found a "carry-over in EEG coherence from the 'Mozart listening condition' to the spatial-temporal reasoning tasks, which may be responsible for the causal enhancement found in behavioral experiments" (Sarnthein et al. in press).

Though the evidence supporting the "Mozart effect" appears convincingly strong, It is interesting that there are no published reports indicating a replication of the "Mozart effect" by other researchers. In fact, there is an increasing number of reports which indicate failure to reproduce the "Mozart effect" using alternative measures of spatial-reasoning. (Stough, Kerkin, Bates, and Mangan 1994; Carstens, Huskins, and Hounshell 1995; Newman, Rosenbach, Burns, Latimer, Matocha, Vogt 1995). Accordingly, it was the researcher's intention to further investigate the supposed "Mozart effect" using an alternative measure of spatial reasoning, two subtests of the Wechsler Adult Intelligence Scale Revised (WAIS-R).

Of interest, also, is whether or not the "Mozart effect" can be attributed only to the

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[2]With respect to the difference in brain development and plasticity for children and adults, it is not expected that enhancements seen in children may actually reflect those of adults.

music of Wolfgang Amadeus Mozart. If an enhancement was to be found with the Mozart piece *and* the music of another composer, this evidence would support that the "Mozart effect" is not composer-specific. To test this hypothesis, the music of a composer from the same era as Mozart was selected. Because Joseph Haydn was a contemporary of Mozart their musical styles are similar, a Haydn piano sonata, written in the same key and at a similar tempo as the famed Mozart piece, was selected.

It was hypothesized that, using either of the two music stimuli, no enhancement would be found for the scores on the spatial reasoning tests. However, if an enhancement were to be found, it would offer more evidence to suggest that it is spatial-reasoning, specifically, which is being enhanced by the Mozart piece.

Lastly, because longitudinal (Hassler, Birbaumer, and Feil 1985), behavioral (Madsen 1990), anatomical (Schlaug, Jäncke, Yanxiong, Huang, Staiger, Steinmetz 1995) and neurophysiological (Birbaumer, Lutzenberger, Rau, Mayer-Kress, Braun, in press; Sergent 1993) evidence suggests that musicians react differently than non-musicians to music, it was the researcher's intention to investigate whether musicians and non-musicians differed in the amount of enhancement which allegedly results from listening to music.

Method

Participants

Sixty-two students (28 women and 34 men) from a small, private, upper-division, liberal arts university participated in the study. Ages ranged from 18 to 22 years with a mean of 19.2 years. Students were not paid for their participation, though some did receive an optioned class credit. Volunteers were asked for their informed consent beforehand and were debriefed at the conclusion of their participation

Materials

Two different musical selections were used in this study. First, in an effort to reproduce the alleged "Mozart Effect," the same sonata used successfully in previous studies (Rauscher et al. 1993, 1995), Mozart's Sonata for Two Pianos in D Major, K.448 (Mozart 1996, track 8), was used in this study. Second, in an effort to reproduce the alleged "Mozart effect" using the music of another composer, Haydn's Piano Sonata in D, Hob. XVI.37 was recruited (Haydn, 1985, track 6). Two spatial-reasoning subtests from The Wechsler Adult Intelligence Scale Revised (WAIS-R), "Digit Symbol" and "Block Design," were used to measure spatial-reasoning performance (Wechsler 1981). Though tests have been created in an effort to standardize the assessment of music proficiency (see McLeish 1966 for a review), for the purposes of this study, participants were operationally described as "musician" or "non-musician," through the use of a subjective evaluation (Birbaumer 1994) which was adopted and revised so as to quantitatively scale self-reported information (see Figure 1).

Apparatus and Procedure

Using a random number chart, volunteers were randomly assigned to one of the three following listening conditions: Mozart, Silence, or Haydn. Each volunteer participated in the study alone. After signing his or her informed consent, the participant was directed into a listening room and asked to sit in a chair positioned in front of a Macintosh PowerMac 8500 computer set-up to play the musical stimulus through headphones at the command of a mouse-click, given by the research assistant. The participant was then handed a pair of headphones as a research assistant gave these directions for the listening portion: "I want you to wear these headphones. Through them you may or may not hear any sound. If you do hear sound, I want you to listen for the following three things: any overall structural contour or form, any changes in dynamics (or volume), and any textural or rhythmic patterns" (see Figure 2). Research assistants who were responsible for giving these directions were advised how to offer further explanation.

Mozart Condition

If the participant was assigned to the Mozart condition, following the listening instructions, the research assistant commanded the computer to start the Mozart selection and stepped out of the room. After 7 minutes and 40 seconds (the length of the first movement) the research assistant returned to the participant and directed him or her toward a seat positioned at a table across from the seated experimenter, who immediately administered the two spatial tests.

Silence Condition

If the participant was assigned to the Silence Condition, following the listening instructions, the research assistant stepped out of the room and returned after 7 minutes and 40 seconds, the length of the Mozart selection. The participant was then directed toward a seat positioned across from the seated experimenter who immediately administered the two spatial tests.

Haydn Condition

If the participant was assigned to the Haydn Condition, following the listening instructions, the research assistant stepped out of the room, waited 2 minutes and 32 seconds, returned to the room and commanded to computer to play the Haydn selection. After, 5 minutes and 8 seconds, the length of the first movement of the Haydn selection, the research assistant returned to the participant and directed him or her toward a seat positioned at a table across from the seated experimenter who immediately administered the two spatial tests.

Questionnaire

After the administration of the spatial tests, the participant was asked to complete a brief questionnaire designed to describe his or her data in terms of musical experience (see Figure 1). The information collected from this assessment was later used to categorize data as those of a "Musician" or "Non-Musician.[3]" Generally, those who rated their ability as 5 or above and reported to practice or perform music at least 8 to 10 hours per week were classified as "musicians." For the data of those participants who rated themselves closer to the cut-off, additional consideration of musical background was taken into account. The Questionnaire was effective in classifying 23 Musicians and 30 Non-Musicians. This accounted for all[4] but 5 sets of data which were deemed ambiguous and, subsequently, dropped from the study.

Results

Raw scores from the tests were converted to scaled scores using a conversion table which is respective to a reference group. Both a between subjects and within subject 2 x 3 analysis of variance was conducted. No main effects of stimulus were found for the combined scores of Musicians and Non-Musicians groups on Digit Symbol (see Figure 3) or Block Design (see Figure 4) subtests (see Table 1 for group means). When the scores of Musician and Non-Musician Groups

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[3]It is important to note that caution should be used in interpreting the term "non-musician," as it can be argued that, by some standard, anyone may be considered a musician. The differentiation made here is only an attempt to find criteria which support a distinction between two more extreme levels of musicianship as indicated by self-report. Additionally, for the purposes of this paper, the words "Musicians" and "Non-Musicians" will be used to refer to the scores of the individuals as classified by the questionnaire. The words "musicians" and "non-musicians" will refer to the more generalized application of these terms.

[4]Two sets of data were dropped from the study due to unsuccessful testing procedures.

on Digit Symbol were separated, there was no significant interaction of Stimulus by Music Group (see Figure 4). However, when scores of Musicians and Non-Musicians groups on Block design were separated, a marginally significant interaction ($p = .055$) of Musicianship by Stimulus condition was found (see Figure 5).

Because the scores of Mozart conditions and Haydn conditions did not statistically differ, these two Music Groups were lumped together to form a lumped Music Group. In this further analysis, no significance interaction was found for scores on Digit Symbol (see Figure 7). However, a significant interaction ($p = .023$) of Stimulus by Musician group was found for the scores on the Block Design test (see Figure 8).

Discussion

No statistically significant results were found to support the hypothesis that listening to the music of Mozart enhances scores of the participants of this study on the two tests used to measure spatial-reasoning ability. Additionally, no statistically significant results were found which suggest that listening to a sonata written by Joseph Haydn enhances the scores of participants on the same two tests designed to measure spatial reasoning ability. Lastly, no statistically significant evidence ($p = .055$) was found to suggest a difference between the response of musicians and non-musicians to musical stimulus.

Though no statistically significant results were found among the stimulus conditions, there are several interesting apparent trends in the data. For both Digit Symbol and Block Design spatial-tests, Musicians seemed to score higher after the Music conditions than after the Silence condition (see Figures 5 & 6). Inversely, for both Digit Symbol and Block Design spatial-tests, Non-Musicians apparently scored higher after the Silence condition than after the Music conditions.

These trends offer justification for further research to investigate the response to musical conditions of musicians and non-musicians and possibly explain why previous research (and this research as well) has failed to reproduce a *recognizable* difference in performance on spatial tests after the administration of a musical stimulus. It can be hypothesized that, when grouped together, the scores of musicians and non-musicians cancel each other out, hiding a difference in performance. Further, to the knowledge of this author, this is the first reported research which has differentiated between musicians and non-musicians in assessing an enhancement in spatial-reasoning attributed to a musical listening condition. Accordingly, because a difference in reaction to a musical stimulus for Musicians and Non-Musicians is *marginally* supported, it can be argued that previous research results may be misleading in that a lack of enhancement in a generalized group could attributed to a musician-level confound.

With the exception of scores from Non-Musicians in Block Design, for both Digit Symbol and Block design, trends in the data indicate no apparent overall difference in response to the Mozart and Haydn conditions (see figures 5 & 6). However, in Block Design, trends indicate that Non-Musicians scored higher after the Mozart condition than after the Haydn condition (see figure 6). Two possible explanation are suggested for these results. First, the literature has indicated that enhancements in spatial reasoning from listening to Mozart are temporary, lasting 10-15 minutes (approximately the length of the stimulus) (Rauscher 1993). The Haydn sonata used in this study is 2 minutes and 32 seconds shorter than the Mozart piece used. Accordingly, it may be suggested that a difference in response to the two sonatas can be attributed to their difference in duration. In accordance with the proposal which suggests that "music acts as an 'exercise' for exciting and priming the common repertoire and sequential flow of cortical firing patterns responsible for higher brain functions," (Rauscher 1995) it is proposed that, in effect, the Haydn sonata, because of its shorter duration, failed to prime the cortical firing patterns of the Non-Musicians as well as the Mozart sonata. Because no difference was apparent for Musicians, it might be further proposed that priming rates for the brains of Musicians and Non-Musicians differ.

Second, the literature suggests that it is the complex structural nature of Mozart's music that is responsible for an enhancement in spatial-reasoning performance (Rauscher et al. 1995). It was this argument that led to the investigation of whether the music of another composer could produce the "Mozart effect." Because Haydn was a contemporary of Mozart and wrote music which used complex structural forms which resembled the music of Mozart, it was proposed that a piano sonata, written in the same key and within a year-and-a-half of Mozart's Sonata for Two Pianos in D major, K.448 (The Mozart sonata was written in January of 1781 and the Haydn sonata was written in November of 1780), would potentially produce an enhancement similar to the one produced by the famed Mozart piece. An arguable differentiation between the two pieces is that the composing strategies used to write the Mozart sonata offer a piece which is structurally more accessible to the listener than the sonata written by Haydn. Accordingly, the scores of Musicians, who are trained to decipher structural components despite ambiguities, such as those often present in the works of Haydn, apparently did not reflect the different levels of accessibility between the two pieces (see figure 6). However, the scores of the Non-Musicians, who, due to their lack of training in deciphering the more structurally ambiguous components of the Haydn piece, apparently did reflect the different levels of accessibility between the two pieces (see figure 6).

In additional statistical analysis, with the scores of participants separated into Musicians and Non-musicians groups, the Block Design scores from Mozart and Haydn conditions were added together to form a more general Music condition[5]. A significant interaction ($p = .023$) was found between the Music condition and Musician group. This analysis indicates that there is a significant difference between the scores of Musicians and Non-Musicians in the music condition (see figure 7).

The statistical significance of these results should be interpreted with care, as, the merged Music group is nearly twice as large as the silence group. However, this finding does offer additional support for the suggestion that the scores of musicians and non-musicians were apparently affected by this particular type of music, classical period keyboard music.

There are limitations which should be addressed when using this study as a platform for further research. First, larger groups should be used for each categorization. Enhancing the size of groups should, if the interpretation of the data is supported, statistically strengthen the apparent trends. Second, because an expectancy confound may be introduced when participants, unknowingly placed in the silence condition, are asked to wear headphones, it may be of interest to administer all musical stimulus through speakers rather than through headphones.

Conclusion

The findings in this study suggest that further testing with a larger sample size is warranted to determine whether a discernible difference exists between the performance of musicians and non-musicians on spatial reasoning tests after listening to a Mozart sonata or a Haydn sonata.

It is also of interest to investigate whether less structurally accessible music, such as that

[5]Though this condition has been named Music, the interpretations of the results do not apply to music in general, or even to classical music in general. Rather, more specifically, the results of this analysis can only help support speculations concerning late 18th-century Germanic piano music.

written by Beethoven or Schuman, will produce different levels of enhancement for musicians and non-musicians. Additionally, it is worthwhile to investigate whether a variety of other musically relevant variables may have an influence on spatial reasoning. It is suggested that future studies may begin investigating the following: 1) possible differences between monochromatic instruments (such as a piano) and polychromatic instruments (such as strings); 2) single instrument compositions (such as sonatas or concertos) versus multiple instrumental compositions (such as symphonies); 3) texted and non-texted works.

The results of this study suggest that an area of the brain involved in spatial-reasoning may be influenced, or altered, by the attentive listening of music. It is proposed that further research using individuals with different levels of musical experience, music of various accessibility levels, and investigational techniques such as EEG and other brain imaging devices may offer a more tangible perspective into the relationships apparently existent among music, spatial reasoning, and the development of the musical mind.

Figure Caption

Figure 1. Questionnaire used to classify the data of participants as Musician or Non-Musician.

Figure 2. Procedure followed by research assistants.

Figure 3. Mean scores of combined Musician and Non-Musician groups for stimulus conditions on the Digit Symbol test.

Figure 4. Mean scores of combined Musician and Non-Musician groups for stimulus conditions on the Block Design test.

Figure 5. Mean scores for divided Musician and Non-Musician groups for stimulus conditions on the Block Design test.

Figure 6. Mean scores for divided Musician and Non-Musician groups for stimulus conditions on the Block Design test.

Figure 7. Compared Means of Musician Groups for Digit Symbol, respective to Lumped Music Stimulus.

Figure 8. Compared Means of Musician Groups for Block Design, respective to Lumped Music Stimulus, shows significant interaction ($p = .023$) of Lumped Music Stimulus by Musician Group.

Table 1
Mean Scaled Scores for Digit Symbol and Block Design

Type of Test	Stimulus		
	Mozart	Silence	Haydn
Digit Symbol			
Musicians	14.2	12.9	14.1
Non-Musicians	12.7	13.3	12.7
Block Design			
Musicians	14.0	12.8	14.3
Non-Musicians	12.5	14.2	11.4

Figure 1

Questionnaire for Assessing Musical Experience

Note: for scale of 1-7, (1) is lowest and (7) is highest

1) On a scale of 1-7, how do you estimate your own musical capability?

2) How many hours a week do you practice/perform music?

3) How many hours a week do you hear/listen to music?

4) On a scale of 1-7, how much do you like classical music?

5) On a scale of 1-7, how much do you like popular music?

6) Which instruments do you play?

7) On a scale of 1-7, how do you estimate your rhythmic capability?

8) On a scale of 1-7, how much do you like dancing?

9) On a scale of 1-7, how much do you like Jazz?

10) How much and which kind of musical education have you had?

For Example:

3 Semesters	voice lessons	College
2 Yrs	Trumpet	Elementary

Theory (2 sem), Music History (2 sem), Analysis, Conducting, Ensemble (7 sem)

Figure 2

Procedure

Greet and Sign Consent Form
- Introduce Assistant

ASSISTANT [You will need a stop watch.]

"Please have a seat. I'd like you to wear these headphones. Through them you may or may not hear any sound. If you do hear sound, please listen for
- any overall structural form or contour.
- any changes in dynamics, (or changes in volume)
- any textural or rhythmic patterns.

Hand the volunteer the pair of headphones

Select the stimulus using the RANDOM CHART

if MOZART
Insert the Mozart CD and play track #8 only (7 min 40 sec)

if SILENCE
Insert either CD into the computer but do not play it. Have the volunteer listen to silence for (7 min 40 sec)

if HAYDN
Insert the Haydn CD but do not play it yet. Instead, have the volunteer wait for (2 min 32 sec). Then play track #6 only. It will last (5 min 8 sec).

The CD will stop automatically.

"O.K. Now I'd like you to follow me over here and have a seat. *(Have the volunteer sit across from the experimenter.)*

Figure 3

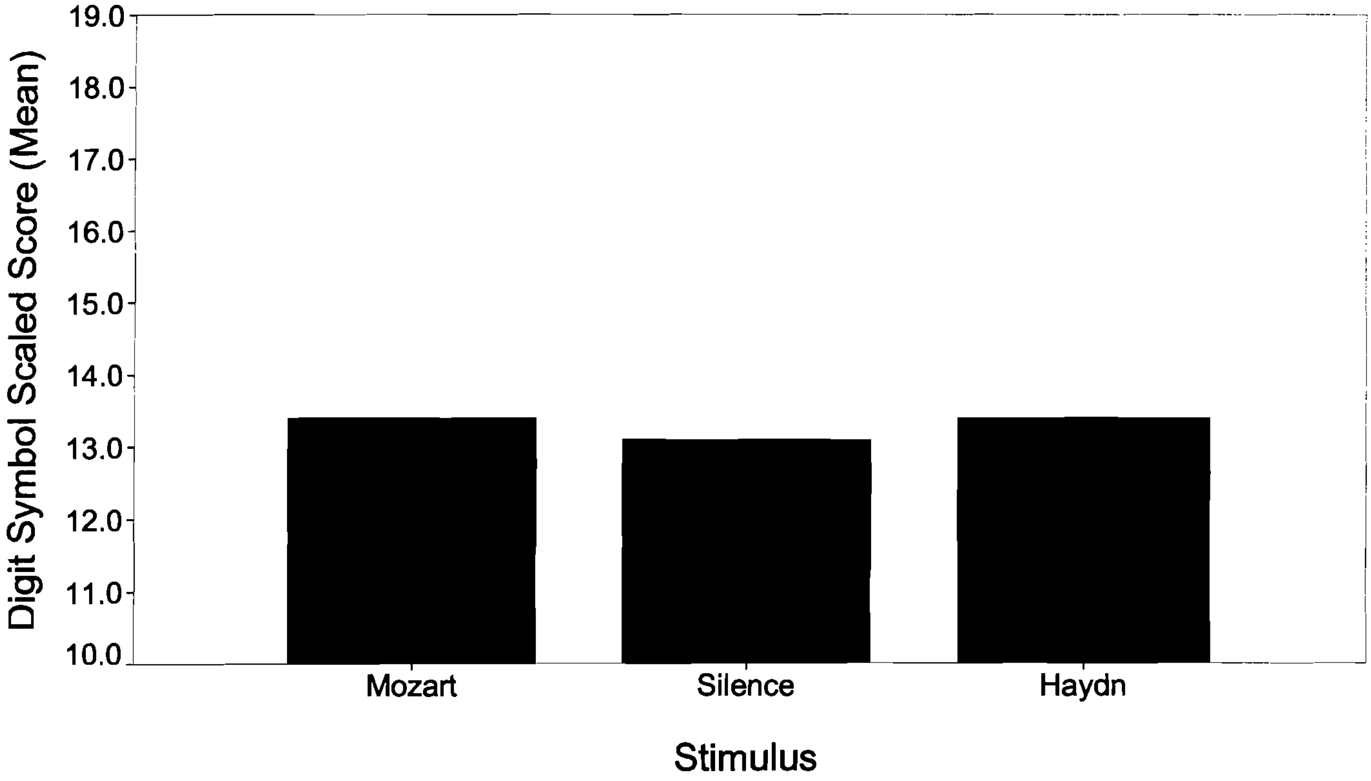
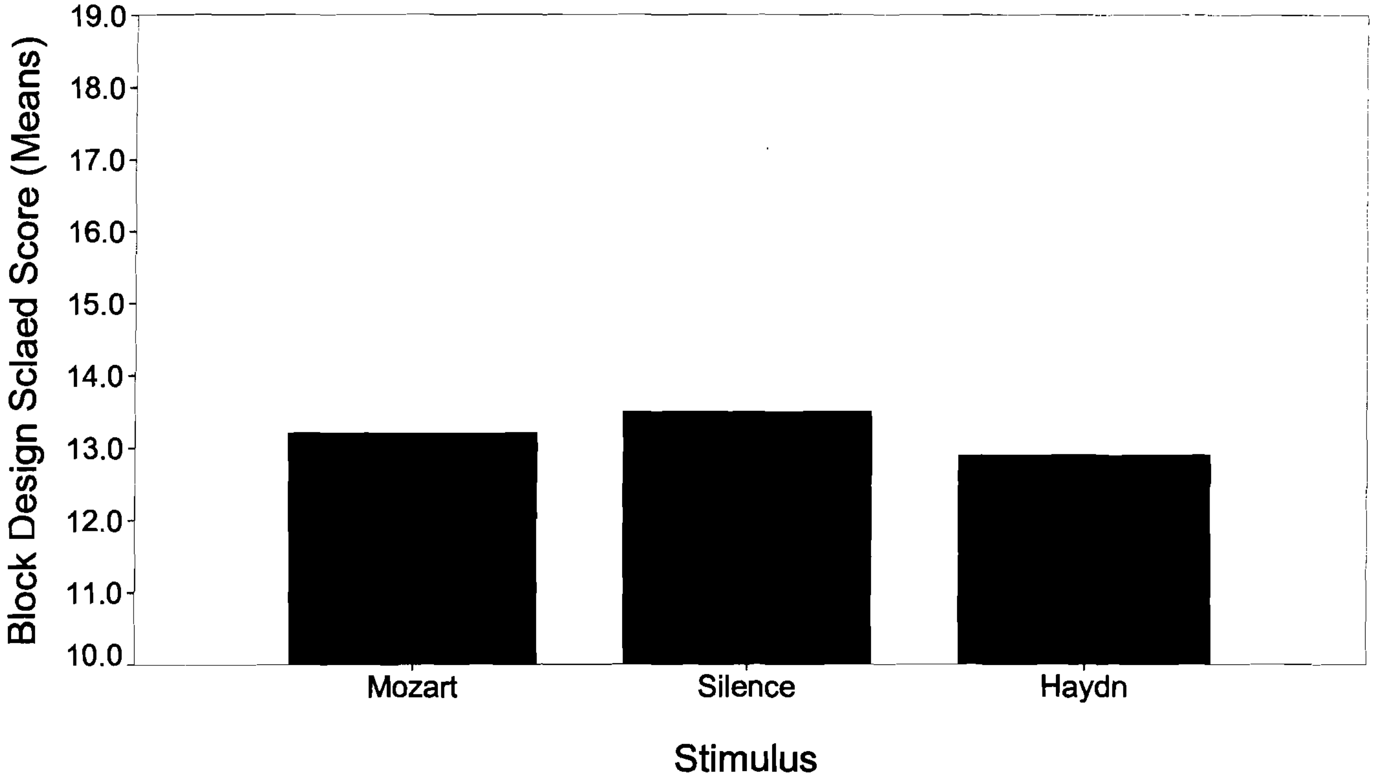
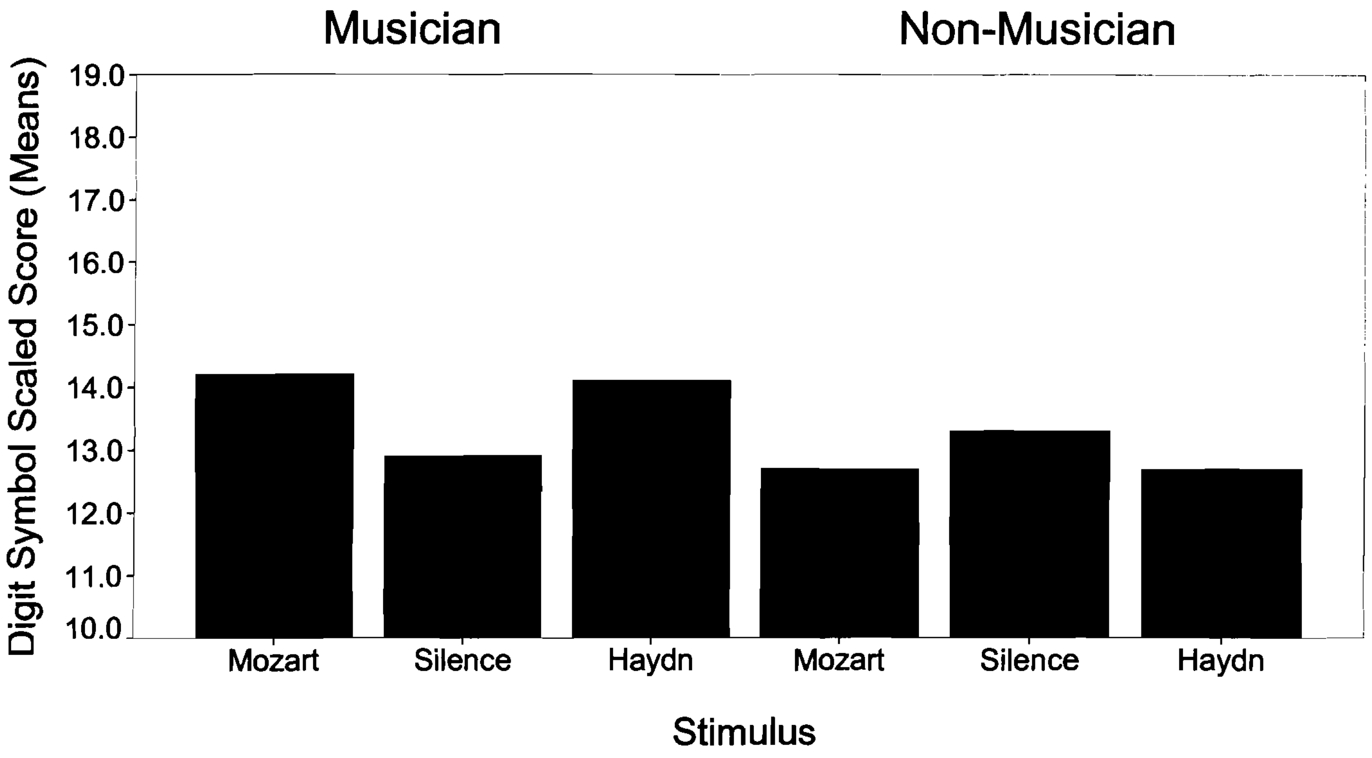

19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
Digit Symbol Scaled Score (Mean)
Mozart
Silence
Haydn
Stimulus

Figure 4



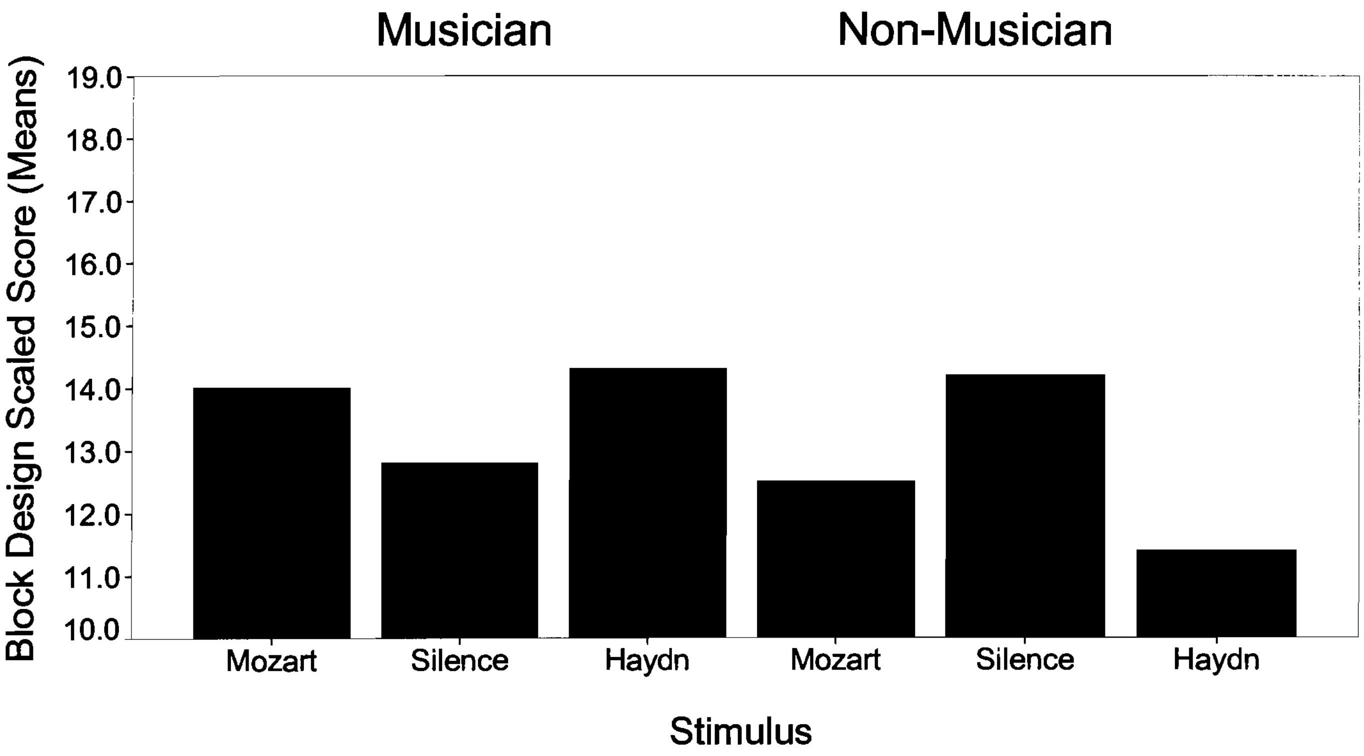
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
Block Design Sclaed Score (Means)
Mozart
Silence
Haydn
Stimulus

Figure 5



Musician
Non-Musician
Digit Symbol Scaled Score (Means)
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
Mozart
Silence
Haydn
Mozart
Silence
Haydn
Stimulus

Figure 6



Musician
Non-Musician
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
Block Design Scaled Score (Means)
Mozart
Silence
Haydn
Mozart
Silence
Haydn
Stimulus

Figure 7

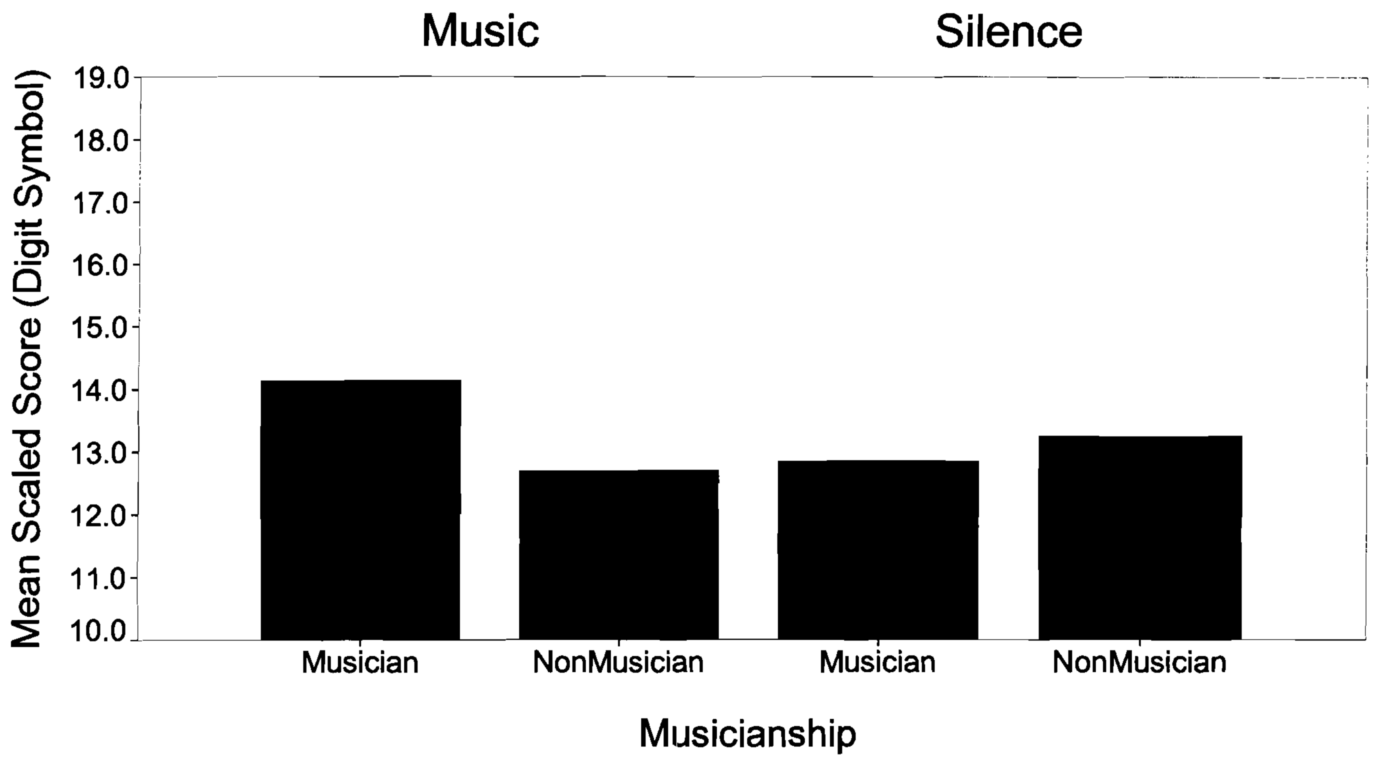
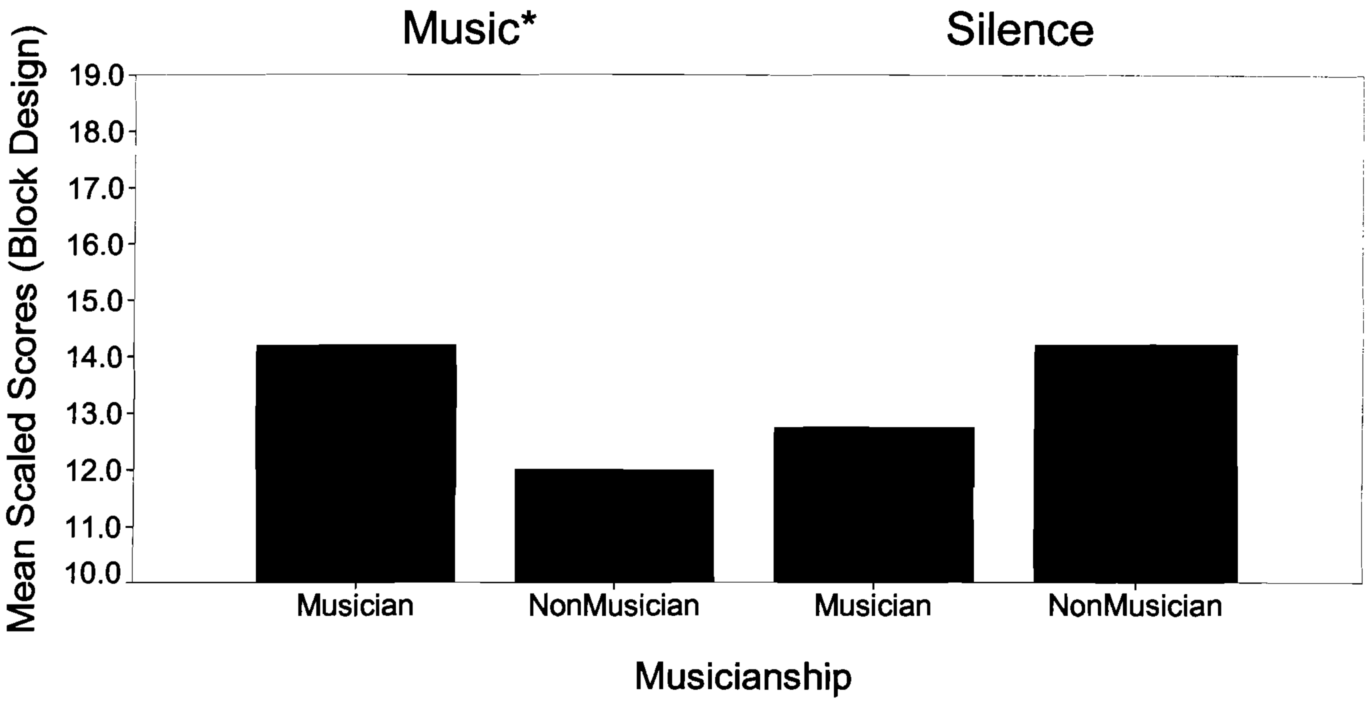

Music
Silence
Mean Scaled Score (Digit Symbol)
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
Musician
NonMusician
Musician
NonMusician
Musicianship

Figure 8



* significant interaction of Stimulus by Musician Group (p = .023)

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