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The effect of music on visuospatial memory

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THE EFFECT OF MUSIC ON VISUOSPATIAL MEMORY

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Abstract

Music was utilized in an attempt to enhance visuospatial memory. Twenty-eight individuals, who attended a United Methodist Church in southern West Virginia, were randomly assigned to experimental and control conditions. The experimental group was exposed to new age and classical compositions, counterbalanced for order effects. The new age and classical selections were of similar tempo and complexity. The control group received two relaxation periods, of a comparable length to the music presented to the experimental group. The 7/24 Spatial Recall Test was used to measure visuospatial memory. The measure was administered to each participant immediately after exposure to the music or the relaxation period. The results of the one-way analysis of variance (ANOVA) did not demonstrate a significant difference between the experimental and control groups ($F = 3.559$, ns). A within subjects F-test found no significant difference between the new age and classical compositions utilized as a treatment within the experimental condition ($F = 0.076$, ns). The contributing factors that may have been responsible for the findings and avenues for future research in the area are discussed.

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The Effect of Music on Visuospatial Memory

Memory is a prerequisite for learning to occur. Any method found to enhance cognitive functioning would be of great benefit to both the individual and society. More specifically, music has been associated with the significant enhancement of spatial abilities (Rauscher, Shaw, & Ky, 1993; Rauscher, Shaw, Levine, & Ky, 1994). This study will review the major processes involved in memory and examine the effect of music on visuospatial memory.

Over the past century, many researchers (Ebbinghaus, 1885, as cited in Haberlandt, 1997; Pavlov, 1927; Hebb, 1949) have sought to identify the cognitive processes responsible for memory. Ebbinghaus used nonsense syllables to assess encoding and retrieval ability. Through self-observation, Ebbinghaus found that frequent repetition can fix mental associations in memory. Pavlov, in experiments with canines, found that when one stimulus was paired with a stimulus that elicits a response, the former comes to elicit a similar response when presented independently of the unconditioned stimulus. The results of Pavlov's research strengthened the theory of associationism as an explanation for memory. When two factors are presented simultaneously an association is formed, so that one presented in isolation triggers the other. Hebb postulated that neural pathways become associated when activated concurrently. The connections are strengthened upon successive activations. Over time, with repeated stimulation of the circuit, activation of one pathway energizes the other.

The neurological structure implicated in memory is the hippocampus. The hippocampi are surrounded by the cerebral cortex and are bilaterally distributed in the brain (Haberlandt, 1997). Through Long-Term Potentiation (LTP), the hippocampus is repeatedly stimulated by neural pulses that induce a greater sensitivity to the stimulation. Haberlandt theorized that this activity consolidates immediate and short-term memories into a form more conducive to longer-term storage. The hippocampus contributes to the spatial tracking of information through an analysis of memory relationships or mental mapping (Olton, Collison, & Werz, 1977; Mishkin, & Appenzeller, 1987). The process allows for the coordination of mental representations with that of the actual environment being depicted. Animal research has demonstrated that a lesioned hippocampus inhibits the encoding and retrieval of spatial material.

The temporal lobes also play a major role in the retention or long-term storage of information (Gregory, 1996). Milner (1966) recounted a surgical procedure undertaken to alleviate a patient's intense epileptic seizures. The patient received a bilateral temporal lobe resection that resulted in new memory retention rates of one minute or less. Memories acquired prior to the resection, however, remained intact. Milner speculated that the hippocampus was prevented from transferring the newly acquired, consolidated material to the temporal lobes. The intact memories, on the other hand, had been transferred and were available for retrieval.

Gregory (1996) further clarified the shared memory functions of the hippocampal and temporal structures. The author noted that the processors inhabiting the left hemisphere control verbal memory functions; while visual memory, memory for pictures, faces, and visual stimuli, is processed in the right hemisphere. According to Gregory the the right cerebral hemisphere is responsible for "...the analysis of geometric and visual space, the comprehension and expression of emotion, the processing of music and nonverbal environmental sounds, the production of nonverbal spatial memories, and the tactile recognition of complex shapes" (p. 355).

Memory involves both the encoding and retrieval of information. Several memory theorists have attempted to address the encoding and retrieval process (Baddeley, 1994; Atkinson & Shiffrin, 1968). Working memory is manifested in the cognitive manipulation of information necessary for the utilization of the material. Information enters working memory from short-term or long-term storage (Haberlandt, 1997). The particular store accessed depends on the location of the information, as it relates to current cognitive processes. Baddeley (1994) partitioned working memory into three components: the phonological loop, the visuospatial sketch pad, and the central executive. The phonological loop is active in verbal communication and the memorization of verbal information. Baddeley asserted that if information could be subvocalized the material could be processed in the phonological loop. The visuospatial sketch pad processes spatial and visual imagery. The design and implementation of spatial tasks are assigned to the visuospatial sketch pad. The central executive allocates resources to the two subsidiary systems and coordinates the cognitive activity in working memory.

Atkinson and Shiffrin's (1968) two store model of memory, on the other hand, consists of a short-term and a long-term storage system. The transfer of information, from short-term to long-term memory, is a product of the activities of the hippocampus. The relevant distinction to be made between working memory and short-term memory is that, working memory is active and utilized in the manipulation of data; while short-term memory is a storage facility which lacks computational capabilities. Short-term processing simply transfers information into long-term storage.

According to Leng and Shaw (1991), the ability to recognize patterns, see relationships, and learn the rules that govern the interaction of various elements, stems from higher cognitive processes. The neural patterns activated in the cortex appear to be energized by music. This suggests that the neural pulses transmitted during parallel processing can be triggered by music. Leng and Shaw state that, "Thus in some manner, music may be considered as sort of a 'pre-language'. We propose that music be used as a 'window' into examining higher brain function" (p. 231).

Rauscher, Shaw, and Ky (1993), in a study of the effect of music on spatial reasoning ability, found a significant enhancement effect for the subjects exposed to Mozart's Sonata for Two Pianos in D Major, K448; as demonstrated by scores on the Abstract/Visual Reasoning portion of the Stanford-Binet. Raushcer et al. (1993) suggested using other types of music, of comparable complexity, to further this area of research.

In 1994 Rauscher, Shaw, Levine, and Ky attempted to duplicate the findings from the 1993 study. The authors used the paper-folding-and-cutting subtest from the Stanford-Binet Intelligence Scale as the dependent variable. Rauscher et al. (1994) found a similar enhancement effect for spatial ability. The authors examined visual memory using strings of letters, numbers, and symbols (e.g., A 3 ? C 7) to test retention. No significant enhancement effect for visual memory was found. Baddeley's (1986) theory, that subvocalizable material can be processed in the phonological loop, possibly explains the finding. Letters and numbers have names that most people utilize when referring to them. This would limit the effectiveness of the letter-digit span test used by Rauscher et al. (1994) in the assessment of visuospatial short-term memory, as the stimuli may have been processed as verbal information. Baddeley's theory suggests that the measure needs to consist of abstract symbols.

In an attempt to replicate the Rauscher et al. (1993) study, Stough, Kerkin, Bates, and Mangan (1994), using the Raven Advanced Progressive Matrices, found no statistically significant effect for type of music. Rauscher et al. (1993) postulated that uncomplicated, repetitive types of music would inhibit spatial abilities. In the Stough et al. study the mean score for the dance music condition, while nonsignificant statistically, was below that of the silence condition.

Carstens, Huskins, and Hounshell (1995) used the Revised Minnesota Paper Form Board Test, Form AA, as the dependent variable, in an effort to reproduce Rauscher et al.'s (1993) findings. No significant enhancement effect was found. In a factor analysis of visuospatial elements, Gustafsson (1984) identified three visuospatial factors: spatial orientation, flexibility of closure, and visualization. Carstens et al. (1995) speculated that the inability to replicate the findings of Rauscher et al. (1993), with a different spatial task, may be due to the tasks lower factor loading of a visualization component.

Studies concerned with the enhancement of cognitive abilities through exposure to music have focused on spatial reasoning ability. Little research has been targeted at the visual component of Baddeley's (1986) visuospatial sketchpad. Baddeley proposed using more abstract stimuli in assessing visuospatial memory. Research by Gustaffson (1984) and Carstens et al. (1995) suggests that a more extensive investigation of visuospatial abilities is warranted, utilizing a dependent variable that has a high factor loading of the visual component. According to Rauscher et al. (1993), future research needs to examine the enhancement effects of other styles of music, of comparable form and complexity to that of the Mozart sonata, on spatial abilities.

The focus of this study was to assess the enhancement effects of different styles of complex music on visuospatial memory. Previous findings suggest that complex music will increase visuospatial memory capacity. A significant increase in the rate of encoding and retrieval of information would result in an increase in learning ability.

Hypothesis

Null Hypothesis (H_0): Music will have no significant effect on visuospatial memory.

Hypothesis I (H_1): Classical music will not significantly enhance visuospatial memory more than new age music.

Hypothesis II (H_2): Classical music will not significantly inhibit visuospatial memory more than new age music.

METHOD

Subjects

Thirty subjects, 14 men and 16 women, participated in the research. Twenty-eight were Caucasian and 2 were African-American. The subjects ranged in age from 21 to 54 years. Fifteen subjects were randomly assigned to the experimental group (mean age = 41, SD = 9.49) and fifteen were randomly assigned to the control group (mean age = 40.26, SD = 11.39). The subjects were a sample of the 20 to 55 year old age group that attended a Methodist church in southern West Virginia.

Instrumentation

The 7/24 Spatial Recall Test (7/24) provided a means to evaluate the encoding and retrieval of visuospatial material (Lezak, 1983). Experts in neuropsychological assessment (Barbizet & Cany, 1968; Lezak, 1983; Peyser, Rao, LaRocca, & Kaplan, 1990) consider the 7/24 to possess good construct and criterion related validity.

Developed by Barbizet and Cany in 1968, the 7/24 consists of a stimulus board divided into 24 squares, with 4 squares down and 6 squares across the board. A pattern is created by placing 7 small disks (e.g., poker chips or checkers) in various squares. The subject is allowed 10 seconds to view the placement of the 7 disks. Using 9 disks, the subject is given 15 trials to recreate the original pattern.

Apparatus

Two checker boards (10 1/2 in. x 7 in.) were constructed out of foam-core board. Each board was divided into 24 blocks of alternating black and red squares, with four blocks down and six blocks across the apparatus. One board was used by the subject.

The other board was utilized by the experimenter for the presentation of the stimulus pattern.

A divider (10 1/2 in. x 7 in.) was constructed from the same material. The divider was held between the subject's and the experimenter's boards to obstruct the subject's view of the stimulus pattern. The divider was raised for approximately three seconds when the experimenter presented a stimulus pattern to the subject. A diagram, of the 20 stimulus patterns presented to the subject, was displayed on the side of the divider facing the experimenter.

A total of 16 white poker chips (1 1/2 in. diameter) were utilized for the study. Seven chips were used by the experimenter per pattern, while the subject was given nine chips at the beginning of the session. All patterns consisted of a seven chip arrangement only.

Two audio tapes were recorded with an alternating arrangement of the new age and classical music selections. One arrangement presented the new age piece first. The other tape presented the classical selection first. Approximately 5 minutes and 20 seconds of each composition was recorded and presented to each subject in the experimental group via stereo cassette player.

Procedure

The study was carried out by the researcher. Through preliminary trials on a pilot study, the amount of time allowed to view a stimulus pattern was reduced from 10 to 3 seconds per trial. The modification was undertaken to increase the sensitivity of the instrument to the possible effects of the independent variable. The number of attempts permitted for completion of a stimulus pattern was reduced from 15 to 10 trials. The reduction was necessary to guard against fatigue and promote exposure to all stimulus patterns within a 60 minute time frame.

Standardized presentation procedures were developed to inhibit experimenter bias related to the presentation of instructions and stimulus patterns (see Appendixes B and C for complete instructions and stimulus patterns). The number of trials required by the subject to complete each pattern was recorded on a data sheet, along with educational and work history information (see Appendix D). A letter of consent was received from each participant prior to the collection of any data or information (see Appendix E). Subjects in both the experimental group and the control group received comparable lengths of exposure to their respective conditions, approximately 5 minutes and 20 seconds, of music or relaxation.

The music used in the study was a classical selection, Die Moldau by Bedrich Smetana, and a new age composition, Flying Condor by CUSCO (see Appendix F). The two selections were of comparable form and complexity. A determination of comparability was related to the instrumentation utilized in the piece, tempo, complexity of arrangement, and aesthetic quality. The music was presented to the experimental group only. The treatment began approximately 5 minutes prior to the presentation of the first scored stimulus pattern. A counterbalance technique was utilized to inhibit order effects. The control subjects received no music during the 5 minutes and 20 seconds of relaxation experienced prior to the presentation of the first pattern. During the relaxation period, the control subjects sat quietly with their eyes closed. Both the experimental and control groups received a treatment or relaxation condition and 10 stimulus patterns. The process was then repeated with the appropriate condition and 10 different stimulus patterns. The procedure resulted in a total of 20 different arrangements of poker chips available for presentation to all subjects.

ANALYSIS

The independent variable was music. There were three levels of the independent variable: classical music, new age music, and no music. The dependent variable was the mean number of trials required for the completion of a stimulus pattern on the 7/24 Spatial Recall Test. Twenty-eight subjects, 12 men and 16 women, were included in the final analysis. Five subjects, were unable to complete the task within a 60 minute period. Two of the scores from the 5 subjects, one from the experimental and one from the control group, were randomly dropped from the analysis. The 3 remaining scores, 21% of the experimental group, were assigned the mean score ($M = 2.53$) for that group. The adjustments to the data upheld the assumptions of the analysis of variance.

The mean age for the experimental group was 40.57 and the SD was 9.70. The mean age for the control group was 39.64 and the SD was 11.55. A one-way ANOVA was used to analyze the data, comparing the experimental and the control group variances. Alpha was set at the .05 level of significance for all data analysis. Music had no significant effect on visuospatial memory. Classical music did not significantly enhance visuospatial memory more than new age music. Classical music did not significantly inhibit visuospatial memory more than new age music. The mean number of trials required by the experimental group for completion of the procedure was 2.53 (SD = .558). The mean number of trials required by the control group for completion of the procedure was 2.93 (SD = .576). The mean completion difference of .40 fewer trials for those exposed to the music condition was not statistically significant, $F(1, 26) = 3.56$, ns.

A within subjects F-test was utilized to evaluate the variances of the mean number of trials for the new age (M = 2.55, SD = .671) and the classical composition (M = 2.50, SD =.635) conditions. The difference in completion rates within the music condition was not statistically significant, $F(1, 13) = .076$, ns.

Table 1

Mean Number of Trials for Stimulus Pattern Duplication (and Standard Deviations) by Condition and Type of Music Within Treatment.

	M	SD	n
Relaxation (control) group	2.93	.576	14
Music (experimental) group	2.53	.558	14
(classical) Die Moldau	2.50	.635	14
(new age) Flying Condor	2.55	.671	14

Table 2

ANOVA Summary Table for Relaxation and Music Condition Comparison.

Source of Variation	SS	df	MS	F
Between groups	1.144	1	1.144	3.559
Within groups	8.359	26	0.321	
Total	9.503	27		

Table 3

Within Subjects F Summary Table for New Age and Classical Music Comparison.

Source of Variation	SS	df	MS	F
Type of Music	0.018	1	0.018	0.076
Residual	3.007	13	0.231	

DISCUSSION

Overall, the research indicates that music had no significant effect on visuospatial memory. Neither classical music nor the new age music had a statistically significant enhancement effect on visuospatial encoding or retrieval ability. The research supports the results of Stough et al. (1994), Carstens et al. (1995), and Newman et al. (1995). Stough et al. and Newman et al. utilized advanced forms of the Raven's Progressive Matrices as the dependent variable in their studies. In regard to the abilities tapped by the Raven's Progressive Matrices, Sattler (1982) noted that, "the rule or principle required to solve each item can either be formulated in verbal terms or be derived from a visual perceptual discovery of the internal structure of the stimulus" (p. 309). Visual perceptual observation may be more a function of attention to detail and logical reasoning than the mental manipulation of visual imagery in a temporal capacity. This suggests that the measure may lack the spatial-temporal elements necessary to detect an enhancement effect resulting from exposure to complex music.

Historically, researchers (Rauscher, Shaw, & Ky, 1993; Rauscher, Shaw, Levine, & Ky, 1994; Rideout, Dougherty, & Wernet, 1998; Rideout, & Taylor, 1997; Wilson, & Brown, 1997), who identified a statistically significant enhancement effect of music on spatial reasoning ability, used a paper-folding-and-cutting task or paper-and-pencil-mazes as the dependent variables. Wilson and Brown (1997) were the only researchers to use a measure, other than the paper-folding-and-cutting portion of the Stanford-Binet, to obtain statistically significant findings. It would seem that these tasks share a common element in that they require the individual to mentally manipulate visual imagery in some way. This may be the temporal factor missing in other measures utilized in attempts to gage the effect of complex music on spatial abilities. The research suggests that there may be several different classes of spatial ability. The 7/24 Spatial Recall Test did not require mental manipulation of the stimuli. The test required only the encoding and retrieval of object location. Requiring the subject to create a mirror image of the stimulus pattern, memorizing the arrangement of disks and mentally rotating the pattern 180 degrees, may have added the temporal element found in the other measures.

The small number of subjects involved in the study may have contributed to the nonsignificant finding. A larger sample population may or may not have increased the likelihood of obtaining statistical significance. A larger sample size may have reduced the error of measurement and resulted in a sample statistic that more closely approximated the population distribution. The combined music exposure rates were comparable to that of earlier research (approximately 10 min.). It may be that a greater length of exposure to the music condition would be of nominal benefit in stimulating visuospatial encoding and retrieval functions. There was no statistically significant difference between the classical and new age music conditions, which indicates the compositions were of similar form and complexity.

In the current study, most subjects demonstrated the development of a system to aid in the encoding and retrieval of the stimuli. The speed of acquisition of the system, or the particular strategy utilized, did not appear to be related to the exposure to music. The method of presentation of the various stimulus patterns cued the subject as to when he or she had correctly reproduced the arrangement. Continuously presenting a single pattern until it had been duplicated encouraged the development of a method of processing that was independent of the effects of the music condition. The pattern presentation procedure provided the subject with an opportunity to attempt different methods of encoding and recalling the information (e.g., by the color of squares, dividing the board in half to obtain two smaller patterns, identifying relationships and distances between disks). To discourage the cueing effect, the patterns could have been presented in a series, one after the other. A pattern would be eliminated from the rotation when correctly replicated. This method would be less likely to signal to the subject the correctness of the response. The rotation would continue until all of the patterns had been duplicated or attempted up to 10 trials. The procedure would allow less time for the subject to practice a strategy, on a single pattern, to see what method works best for that arrangement. Based on information gathered at the conclusion of the task, most subjects mentioned utilizing a memory strategy of some type.

Another factor of interest was the mental energy level of the subject at the time the visuospatial memory exercise was performed. Those individuals who were unable to complete the patterns in 60 minutes seemed to experience some difficulty focusing on the task. Interest in the task, individual motivation, and ability to focus attention would all be important variables in the encoding and retrieval of the material. The person may even have been physically tired. These factors could diminish the ability to concentrate and attend to stimuli.

The current study, along with the body of research in spatial ability enhancement, helps to define those spatial-temporal functions that benefit from exposure to classical music. It would seem that the degree of enhancement and the abilities stimulated are of a narrow range. This suggests that the effect may be of little practical use for educational purposes. Future research may attempt to identify individual differences in the ability of music to affect cortical activity. The study indicates that visuospatial memory was not statistically enhanced by either new age or classical compositions. The idea that classical European compositions would be any more cortically stimulating than Far Eastern or Indian selections seems to be an ethnocentric assumption. The continued investigation of the enhancement effects of classical music on spatial ability may be an unproductive area of research.

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Appendix A
Literature Review

Appendix A

Music's ability to augment an emotional experience is widely accepted. The possibility that music may stimulate and enhance other cognitive processes, including those associated with spatial representations in the brain, is less well accepted and understood. The purpose of this research was to evaluate the enhancement effects of music on visuospatial memory. The author will begin the review with a critical examination of the contemporary research regarding the effect of music on reasoning abilities.

Rauscher, Shaw, and Ky (1993), used of 36 undergraduate students, to study the effect of music on spatial reasoning ability. Mozart's Sonata for Two Pianos in D Major, K448, was chosen for the experiment. The within-subjects design consisted of three separate conditions, counterbalanced for order effects: Mozart's Sonata, a relaxation tape, and silence. Each of the three conditions were put into effect 10 minutes prior to testing. The dependent variable was the scores from the Abstract/Visual Reasoning portion of the Stanford-Binet, which consists of four subtests: Pattern Analysis, Copying, Matrices, and Paper Folding and Cutting (Gregory, 1996). A repeated measures ANOVA found a significant enhancement effect for those subjects exposed to the sonata prior to testing, $F(2,35) = 7.08$, $p = 0.002$. The relaxation tape and silence conditions were nonsignificant, Scheffe's $t = 3.41$, $p = 0.002$; $t = 3.67$, $p = 0.0008$. The researchers recommended using music of comparable complexity to further this area of research.

In an attempt to replicate the study (Rauscher et al., 1993) Stough, Kerkin, Bates, and Mangan (1994) used the Raven Advanced Progressive Matrices as the dependent variable. The three music conditions for the study included Mozart's Sonata for Two Pianos in D Major, 448, dance music, and 10 minutes of silence. Thirty subjects were exposed to all three conditions, balanced for order, initiated 10 minutes prior to testing. No significant effect was found for type of music, $F(2,29) = 0.43$, ns. The authors did find, however, an increase in the mean score for the sonata condition ($M = 7.40$, $SD = 2.3$) as compared to the dance music ($M = 7.03$, $SD = 2.34$) and the silence conditions ($M = 7.23$, $SD = 2.56$).

Newman et al. (1995) pretested and posttested 114 students, ages 18 to 51, on the Raven's Progressive Matrices, Advanced Form, to further the research of Rauscher et al. (1993, 1994). The researchers prerecorded instructions and treatment conditions in order to standardize the procedure for the participants. The three treatment conditions included eight minutes of the Mozart sonata, a relaxation procedure, and silence. In a between-subjects analysis, Newman et al. found no significant enhancement effect as a result of the treatment. A practice effect, however, was identified for a within-subjects comparison on pretest to posttest performance for all treatment conditions $F(1,111) = 37.93$, $p < .01$.

The studies, (Newman et al., 1995; Stough et al. 1994) utilizing the Raven Advanced Progressive Matrices as the dependent variable, have been unable to detect the enhancement effect for the treatment condition. Other researchers, (Carstens, Huskins, & Hounshell, 1995) using the Revised Minnesota Paper Form Board Test as the dependent variable, have had similar results in the attempts at identifying the spatially enhancing properties of complex classical music.

Carstens et al. (1995) used the Revised Minnesota Paper Form Board Test, Form AA, in an effort to replicate the research of Rauscher et al. (1993). The between subjects design employed 51 undergraduate students, with 23 subjects in the experimental group and 28 in the control group. Experimental conditions consisted of listening to Mozart's Sonata for Two Pianos in D Major, K448, and meditating for 10 minutes prior to testing. No significant enhancement effect was found for the sonata ($M = 28.7$, $SD = 7.5$) as compared to meditation ($M = 28.1$, $SD = 7.1$).

In a factor analysis of visuospatial elements, Gustafsson (1984) identified three visuospatial factors: spatial orientation, flexibility of closure, and visualization. Carstens et al. (1995) speculated that the inability to replicate the findings of Rauscher et al. (1993), with a different spatial task, may be due to the tasks lower factor loading of a visualization component. Different dependent variables utilized in various studies (Rauscher, Shaw, Levine, & Ky, 1994; Rideout & Taylor, 1997; Wilson & Brown, 1997) identified an enhancement effect which resulted in an increase in the mean score for the treatment group.

Enhancing effects were suggested in music by Mozart other than the Sonata for Two Pianos in D Major. Wilson and Brown (1997) sought to replicate the findings of Rauscher et al. (1993) by utilizing pencil-and-paper mazes to assess spatial abilities. The three prerecorded experimental conditions consisted of 10 minutes of Mozart's Piano

Concerto No. 23 in A Major, K488, relaxation music, and silence. The experimental conditions were presented in three different sequences to 22, 18 to 21 year old, undergraduate psychology students. A 3 x 3 Latin squares design was utilized to analyze experimental conditions across maze difficulty. Wilson and Brown (1997) found that a greater mean number of mazes were completed after exposure to the Mozart concerto (M = 2.68) as compared to the relaxation music condition (M = 2.27) or silence (M = 1.73), $F(2,38) = 9.44$, $p < .001$. The researchers found that a significant mean number of mazes were solved after exposure to the relaxation music as compared to the silence condition $t(21) = 1.97$, $p < .04$.

One of the measures from the Stanford-Binet battery presented by Rauscher et al. (1993), the paper-folding-and-cutting portion of the Abstract/Visual Reasoning segment, was found to be sensitive to the enhancement effects of complex music. Rauscher, Shaw, Levine, and Ky (1994) attempted to replicate the findings from the study. The authors used the paper-folding-and-cutting subtest from the Stanford-Binet Intelligence Scale as the dependent variable. The experimental design utilized 79 undergraduate students divided into three groups. There were 26 students in the silence condition, 27 in the Mozart Sonata condition, and 26 in the mixed condition. The mixed condition consisted of dance music, a recorded story, and Music With Changing Parts by Philip Glass. Each group experienced the assigned condition on four consecutive days. On the first day of testing, the authors identified the various participant's spatial abilities before presenting the experimental conditions. Rauscher et al. (1994) noted the findings of the follow-up study:

> To that end, we performed a two (listening condition: silence and Mozart only) by two (day 1; no exposure, and day 2; first exposure to silence or Mozart) analysis (ANOVA). This analysis revealed a significant main effect for day ($F_{(1,51)} = 28.211$, $p < .001$) and a significant interaction between listening condition and day ($F_{(1,51)} = 11.17$ $p < .01$). (p. 9)

Rauscher et al. (1994) examined the possibility of visual memory enhancement. On the fifth day of research the mixed condition group was divided into two groups. The groups were presented with the Mozart condition and the silence condition prior to the memory exercise. The researchers used strings of letters, numbers, and symbols (e.g., A 3 ? C 7) to test retention. No significant enhancement effect was found for short-term memory (Mozart $M = 7.54$, silence $M = 7.85$), $t = 0.18$, ns. The findings may be the result of the dependent variable used to gage the effect. Baddeley (1986) pointed out that subvocalizable material can be processed in the phonological loop. This would limit the effectiveness of a digit or letter span test in assessing short-term memory associated with the visuospatial sketchpad.

Rideout and Taylor (1997) used 32 undergraduate students, ages 18 to 21, to identify possible enhancement effects elicited by the Mozart sonata. A paper-folding-and-cutting exercise, based on the Stanford-Binet Scale, was used as the dependent measure. Half of the items were taken directly from the Stanford-Binet, the other half were developed by the researchers. Participants were assigned to one of four groups.

Experimental conditions consisted of a relaxation procedure and Mozart's Sonata for Two Pianos in D Major. Experimental conditions and the sequence of forms of the dependent measure were counterbalanced to control for order and practice effects. The mean score for the experimental group ($\underline{M}$ = 11.84, $\underline{SD}$ = 2.89) was greater than the mean for the control group ($\underline{M}$ = 10.78, $\underline{SD}$ = 3.47), $\underline{t}(31) = 1.91$, $\underline{p} < .05$, 1-tailed. Practice effects were identified through an analysis of a mean increase in scores overall (increase $\underline{M}$ = 2.25, $\underline{SD}$ = 2.37), $\underline{t}(31) = 5.28$, $\underline{p} < .01$.

Rideout, Dougherty, and Wernert (1998) elaborated on the Rideout and Taylor (1997) study by including a contemporary piece of music as an experimental condition. The three experimental conditions were comprised of the Mozart sonata, a contemporary selection, and prerecorded relaxation instructions. The contemporary music was Acroyali/Standing in Motion, by Yanni. According to the authors, the piece appeared to be comparable in complexity to that of the Mozart sonata. The procedure involved eight groups in which experimental conditions and the sequence of forms of the dependent measure were counterbalanced to control for order and practice effects. Sixteen men and 16 women undergraduate students, ages 17 to 22, were involved in the research. Alternate forms of a paper-folding-and-cutting test were used as the dependent measure. The relaxation procedure was utilized as a control for all music conditions. The Mozart condition ($\underline{M}$ =13.4, $\underline{SD}$ = 1.9), $\underline{t}(15) = 1.96$, $\underline{p} < .05$, 1-tailed, and the Yanni condition ($\underline{M}$ = 12.7, $\underline{SD}$ = 3.3), $\underline{t}(15) = 3.52$, $\underline{p} < .01$, showed an increase in mean score over that of the control condition ($\underline{M}$ = 12.5, $\underline{SD}$ = 2.7; $\underline{M}$ = 11.4, $\underline{SD}$ = 2.3).

Overall, the studies have primarily been concerned with the musical enhancement of spatial reasoning ability. Little research has been targeted at the visual component of Baddeley's (1986) visuospatial sketchpad. Baddeley proposed using more abstract stimuli in assessing visuospatial memory. Gustaffson (1984) and Carstens et al. (1995) also suggest that a more extensive investigation of visuospatial abilities is warranted, utilizing a dependent variable that has a high factor loading of the visual component. According to Rauscher et al. (1993) and Rideout et al. (1998) further research is needed to evaluate the enhancement effects of other styles of music, of comparable form and complexity to that of the Mozart sonata.

The focus of this study was to assess the enhancement effects of different styles of complex music on visuospatial memory. Previous findings suggest that complex music will increase visuospatial memory capacity. A significant increase in processing speed would allow for memory enhancement and result in improved levels of learning.

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Appendix B
Instructions to Subjects

Appendix B

Before we begin I would like to address two points. First, this is not an intelligence test. It is not a personality test. Do not think of this as a test. Secondly, no individual data sheet will be analyzed in isolation. Only group comparisons will be made after all of the data have been collected. Relax, view the procedure as a game and try your best.

In just a minute you will be asked to close your eyes and sit quietly, for a period of approximately five minutes.

EX> ...and listen to a piece of music.

During this time you can relax.

EX> When the song ends, open your eyes.

CON> At the conclusion of the relaxation period, I will signal you to open your eyes.

You will then view various patterns of disks on a board and attempt to duplicate the patterns on your own board. You can take as much time as you need to copy the pattern.

(GIVE THE PARTICIPANT NINE WHITE POKER CHIPS AND A BOARD.)

Let's try a couple of example patterns. Try this one.
(ALLOW A THREE SECOND VIEWING PERIOD. ALLOW AS MANY TRIALS AS NECESSARY TO DUPLICATE THE PATTERN CORRECTLY. WHEN CORRECT SAY "GOOD.")

(Example #1) = (3, 8, 10, 13, 15, 17, 24)

Note: Visual pattern representation utilized in procedure.
Numerical pattern representation (coordinate system) utilized in document for practical purposes.

Appendix B (cont.)

Let's try another example. Try this one.
(ALLOW A THREE SECOND VIEWING PERIOD. ALLOW AS MANY TRIALS AS NECESSARY TO DUPLICATE THE PATTERN CORRECTLY. WHEN CORRECT SAY "GOOD.")

(Example #2) = (1, 9, 10, 13, 15, 16, 18)
Note: Visual pattern representation utilized in procedure.
Numerical pattern representation (coordinate system) utilized in document for practical purposes.

You are now familiar with the procedure. Close your eyes and relax.

EX> (START THE APPROPRIATE MUSIC FOR THE EXPERIMENTAL GROUP.)
CON> (BEGIN TIMING THE RELAXATION PERIOD FOR CONTROL GROUP.)

(AFTER THE PARTICIPANT OPENS THEIR EYES CONTINUE.)
We are now ready to begin. Remember, you can take as much time as you need to copy the pattern. Copy the exact pattern you see. Do you have any questions?

****
PRESENT TEN PATTERNS TO THE PARTICIPANT. ALLOW THREE SECONDS VIEWING TIME FOR EACH PATTERN. ALLOW NO MORE THAN TEN TRIALS PER PATTERN. AFTER TEN DIFFERENT PATTERNS HAVE BEEN ATTEMPTED BY THE PARTICIPANT REPEAT THE PROCEDURE. BEGIN PHASE TWO UPON THE COMPLETION OF THE SECOND MUSIC/RELAXATION PHASE.
(PATTERNS A1--A10 AND B1--B10 FOUND APPENDIX C.)
****

Now we are going to repeat the process. In approximately five minutes you will be given the remaining patterns to duplicate. Close your eyes and relax.

EX> (START THE APPROPRIATE MUSIC FOR THE EXPERIMENTAL GROUP.)
CON> (BEGIN TIMING THE RELAXATION PERIOD FOR CONTROL GROUP.)

(AFTER THE PARTICIPANT OPENS THEIR EYES CONTINUE.)

Remember, you can take as much time as you need to copy the pattern. Copy what you see. Do you have any questions?

Appendix C
Visuospatial Patterns

Appendix C

Stimulus Board Coordinates

Row #1	(1..........6)
Row #2	(7.........12)
Row #3	(13.......18)
Row #4	(19.......24)

Visuospatial Patterns

Example #1 = (3, 8, 10, 13, 15, 17, 24)

Example #2 = (1, 9, 10, 13, 15, 16, 18)

A-1 = (2, 5, 6, 13, 16, 18, 21)	B-1 = (3, 5, 7, 11, 15, 20, 23)
A-2 = (5, 8, 10, 13, 18, 22, 24)	B-2 = (3, 5, 7, 16, 20, 22, 24)
A-3 = (4, 8, 11, 12, 14, 16, 19)	B-3 = (2, 4, 6, 10, 13, 17, 21)
A-4 = (1, 5, 9, 13, 18, 20, 22)	B-4 = (3, 5, 6, 8, 16, 18, 19)
A-5 = (1, 4, 6, 9, 17, 20, 21)	B-5 = (1, 3, 5, 12, 14, 16, 23)
A-6 = (3, 7, 10, 12, 14, 22, 24)	B-6 = (1, 6, 10, 14, 18, 22, 24)
A-7 = (2, 10, 12, 13, 15, 19, 23)	B-7 = (4, 6, 8, 10, 13, 21, 22)
A-8 = (1, 3, 11, 13, 16, 20, 24)	B-8 = (2, 6, 10, 13, 14, 18, 22)
A-9 = (3, 7, 11, 15, 19, 23, 24)	B-9 = (1, 3, 6, 10, 18, 19, 21)
A10 = (2, 8, 10, 12, 13, 21, 23)	B10 = (2, 7, 11, 15, 16, 20, 24)

Note: Visual pattern representation utilized in procedure.
Numerical pattern representation (coordinate system) utilized in document for practical purposes.

Appendix D
Data Collection Sheet

Appendix D

VISUOSPATIAL MEMORY DATA SHEET

ID# __________

AGE: _____ GENDER: Male / Female Race: White / Nonwhite

EDUCATION: Grade School / HS / Vocational / College / Graduate School

OCCUPATION: Professional / Business / Clerical / Sales / Manual / Service

HOBBIES:____

A-1	1	2	3	4	5	6	7	8	9	10
A-2	1	2	3	4	5	6	7	8	9	10
A-3	1	2	3	4	5	6	7	8	9	10
A-4	1	2	3	4	5	6	7	8	9	10
A-5	1	2	3	4	5	6	7	8	9	10
A-6	1	2	3	4	5	6	7	8	9	10
A-7	1	2	3	4	5	6	7	8	9	10
A-8	1	2	3	4	5	6	7	8	9	10
A-9	1	2	3	4	5	6	7	8	9	10
A10	1	2	3	4	5	6	7	8	9	10

B-1	1	2	3	4	5	6	7	8	9	10
B-2	1	2	3	4	5	6	7	8	9	10
B-3	1	2	3	4	5	6	7	8	9	10
B-4	1	2	3	4	5	6	7	8	9	10
B-5	1	2	3	4	5	6	7	8	9	10
B-6	1	2	3	4	5	6	7	8	9	10
B-7	1	2	3	4	5	6	7	8	9	10
B-8	1	2	3	4	5	6	7	8	9	10
B-9	1	2	3	4	5	6	7	8	9	10
B10	1	2	3	4	5	6	7	8	9	10

Appendix E
Consent Form

Appendix E

411 Paint Street
Beckley, WV 25801
January 9, 1999

Dear ________,

As you may or may not know, I hope to graduate with a M.A. in Psychology from Marshall University Graduate College this May. One of the requirements for the degree is the completion of an original research project that makes a contribution to the field of psychology. The area that I am interested in studying deals with visual information processing. Your participation, which would help assure a viable sample population, is very important to the project. The assistance would be greatly appreciated.

The data collection procedure is simple and straightforward. If you have ever played checkers you can follow the procedure. It should require no more than a single 30 to 40 minute session, conducted at your convenience in the comfort of your home. As a participant, you are entitled to the results of the study once the data have been collected and analyzed. Data will be protected by a coding system that utilizes identification numbers to maintain participant confidentiality.

To maintain the validity of the study it is necessary that you refrain from discussing this letter, the procedures for data collection, and any other information connected with the research until all data have been collected and analyzed. The secrecy will also help to ensure confidentiality.

Data collection will be conducted at your convenience. Data collection will begin on 1-15-99 and conclude on 2-28-99. A debriefing session will be conducted upon the completion of the project. Once again, your participation in the study is very important and it would be greatly appreciated. The process should be interesting and fun.

Sincerely,

James L. McCracken

Please check the appropriate box.

Yes, I wish to participate in the study............☐

No, I do not wish to participate.....................☐

Informed Consent Verification

________________________________ ____-____-____ ______-________

Signature of Participant Date Telephone Number

PLEASE RETURN THE COMPLETED FORM IN THE ENCLOSED STAMPED ENVELOPE.

Appendix F
Musical Compositions

Appendix F

(classical) Smetana: Moldau, Vysehrad.
Die Moldau, La Moldava. 1987 Polydor International GmbH, Hamburg.
Manufactured and Marketed by Polygram Classics, a division of Polygram Records, Inc., New York, NY.

(new age) CUSCO: Flying Condor
Higher Octave Music, Evolution: 1986-1996
Manufactured and Distributed by Higher Octave Music.
1996 Higher Octave Music Inc., Malibu, CA.