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AN EXAMINATION OF AN ENHANCING EFFECT OF MUSIC ON ATTENTIONAL ABILITIES IN OLDER PERSONS WITH MILD COGNITIVE IMPAIRMENT^{1,2}

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Summary

While the effect of listening to music on cognitive abilities is highly debated, studies reporting an enhancing effect of music in elderly populations appear to be more consistent. This study considered the effect of listening to music on attention in groups of cognitively normal older adults and those with mild cognitive impairment. Participants were exposed to both a music and silence condition, and after each condition performed Digit Span and Coding tasks which require attention for maximal performance. The hypothesis that listening to music compared to a silence condition enhances performance was not supported for either group. Various explanations for these findings are considered.

There has been controversy over whether or not music improves cognitive performance, ever since a highly controversial study by Rauscher, Shaw, and Ky (1993) found that college students' scores on spatial IQ tests improved after exposure to a ten minute Mozart piano piece. This specific phenomenon has subsequently been referred to as the Mozart effect, and while some researchers have reproduced these findings (Rauscher, Shaw, & Ky, 1995; Rideout & Laubach, 1996; Rideout & Taylor, 1997), other attempts have been unsuccessful (Stough, Kerkin, Bates, & Mangan, 1994; Steele, Bass, & Crook, 1999; Newman, Rosenbach, Burns, Latimer, Matocha, Vogt, 1995; Nantais & Schellenberg, 1999). A meta-analysis of studies looking at the influence of music on cognition by Chabris (1999) cast further doubt on the reliability and generalizability of the phenomenon, as well as on the theoretical explanation for the Mozart effect as put forward by Rauscher, *et al.* (1995). Multiple subsequent studies have supported the hypothesis that an enhancing effect of music on cognitive performance is modulated by an enhancement of arousal (e.g., Thompson, Schellenberg, & Husain, 2001; Roth & Smith, 2008).

While conflicting results have been observed in studies with healthy, usually young adult populations, enhancing effects of music on the cognitive abilities of older adults are more consistently observed (Foster & Valentine, 1998; 2001; Irish, Cunningham, Walsh, Coakley, Lawlor, Robertson, *et al.*, 2006; Thompson, Moulin, Hayre, & Jones, 2005; Mammarella, Fairfield, & Cornoldi, 2007). The lack of consistency reported in studies using younger populations may be due to ceiling effects in task performance during non-music conditions,

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making it difficult to measure improvements during music conditions. Older adults, on the other hand, may not perform at optimal levels due to cognitive or attentional deficits associated with normal or pathological aging. Studies showing performance enhancement specifically on memory and attentional tasks in Alzheimer's disease patients corroborate the idea that music can improve performance when deficits in those cognitive abilities exist (Foster & Valentine, 1998; 2001; Irish, *et al.*, 2006, Thompson, *et al.* 2005).

Studies examining music-related improvements in cognitive performance have often focused on the performance of Alzheimer's disease patients. However, to our knowledge, no published studies have examined whether an enhancing effect of music on cognitive performance is observed in older adults with amnesic mild cognitive impairment, a transitional stage between normal aging and dementia (Petersen, 2000). Individuals are classified as having amnesic mild cognitive impairment when memory impairment is detected via clinical examination but instrumental activities of daily living remain generally intact (Petersen, Smith, Waring, Ivnik, Tangalos, & Kokmen, 1999). Co-existing attentional and executive functioning difficulties involving both sustained attention and set shifting are also reported (Belleville, Chertkow, & Gauthier, 2007; Silveri, Realì, Jenner, & Puopolo, 2007; Traykov, Raoux, Latour, Gallo, Hanon, Baudic, *et al.*, 2007). Individuals with amnesic mild cognitive impairment make up an important group to study given their vulnerability to Alzheimer's disease progression, with an annual rate of conversion approximately ten times that observed for a normal elderly population (Petersen, Doody, Kurz, Mohs, Morris, Rabins, *et al.*, 2001; Gauthier, Reisberg, Zaudig, Petersen, Ritchie, Broich, *et al.*, 2006). A positive influence of music in this population could provide a potential intervention to maintain or improve cognitive performance. Additionally, differential enhancement of cognitive abilities in response to music listening between persons with mild cognitive impairment and cognitively normal older adults could be used as a tool in the early detection of preclinical dementia and to identify individuals at high risk for progression. Janata, Tillmann, and Bharucha (2002) observed that listening to music activates general attention and working memory areas of the brain including bilateral temporal (superior temporal gyrus), parietal (intraparietal sulcus), and frontal (precentral sulcus, inferior frontal sulcus and gyrus, and frontal operculum) regions. As the temporal lobes are especially vulnerable in patients with amnesic mild cognitive impairment and Alzheimer's disease (Braak & Braak, 1991; Convit, de Asis, de Leon, Tarshish, De Santi, Rusinek, 2000; Detolledo-Morrell, Sullivan, Morrell, Wilson, Bennett, Spencer, 1997; Wang, *et al.*, 2009), it might be expected that normal older adults and those with preclinical dementia would show distinct patterns of performance enhancement after listening to music as a result of differential activations in these affected regions.

The current study investigated whether an enhancing effect of music would be observed in patients with mild cognitive impairment. Digit Span and Coding, attentional tasks from the Repeatable Battery for the Assessment of Neuropsychological Status (Randolph, 1998), were administered. Performance on one of these measures (Forward Digit Span) has been found to improve in older adults while listening to music (Mammarella, *et al.*, 2007). Because performance on these tasks is often impaired in persons with mild cognitive impairment and very early Alzheimer's disease (Flicker, Ferris, & Reisberg, 1991; Goldman, Baty, Buckles, Sahrman, & Morris, 1999), it was anticipated that performance would not be at ceiling, allowing for the detection of possible beneficial effects of music. Based on prior studies demonstrating an enhancing effect of music on attentional measures, it was hypothesized that listening to music would improve performance in patients with mild cognitive impairment.

Methods

Participants

Patients with mild cognitive impairment enrolled in this study were participants in the Emory Alzheimer's Disease Research Center or were being evaluated for workups in the Memory Assessment Clinics at the Wesley Woods Center on Aging. These patients and their representatives gave informed consent using forms approved by the Emory University Institutional Review Board. As part of their routine evaluations, patients received neurologic exams, blood tests, and brain scans to assist with diagnosis.

The final sample included 12 patients (M age = 74.3 yr., SE = 2.4; M education = 15.7, SE = .56 yr.; 3 women and 9 men) who were diagnosed with amnesic mild cognitive impairment by experienced neurologists and neuropsychologists, using the criteria of Petersen, Stevens, Ganguli, Tangalos, Cummings, and DeKosky (2001), including a subjective memory complaint (corroborated by an informant), an objective memory impairment (scores >-1.5 SD s below the mean, based on demographically comparable norms), intact general cognitive functioning, and preserved instrumental activities of daily living. Twelve cognitively intact community residing volunteers were recruited as a comparison group (M age = 66.1 yr., SE = 2.9; M education = 16.2, SE = .67; 8 women and 4 men). Exclusion criteria for participants with mild cognitive impairment and the control group were a pre-existing or current neurological disorder (e.g., stroke, Parkinson's disease), alcohol or drug abuse, severe psychiatric disorder (e.g., schizophrenia), and mood disorder (e.g., major depression). There were no significant differences in education ($F_{1,22} = .33$, $p = .57$, unstandardized effect size (Δ) = $-.50$), or the distribution by sex, (Fisher's Exact Test, $p = .10$) between patient and control groups. However, there was a significant difference in age ($F_{1,22} = 4.81$, $p = .04$, $\Delta = 8.17$), as patients with mild cognitive impairment were older than the controls.

Design

This study used a repeated-measures mixed design with group (mild cognitive impairment versus cognitively normal older controls) as the between-subjects variable and music condition (music versus silence) as the within-subject variable. Participants had two trial conditions of attentional tests (Digit Span and Coding), which were administered after 10 min. of listening to music and after 10 min. of silence. Digit Span was always administered before Coding.

Measures

Repeatable Battery for the Assessment of Neuropsychological Status

(RBANS): Attention Index—Digit Span and Coding are the two subcomponents of the Attention Index of the RBANS. Digit Span requires participants to repeat, in the same order, a string of numbers read aloud to them. The span is increased by one digit for each successful trial. The test is terminated when a participant either fails to reproduce the correct sequence for two consecutive strings with the same number of digits or the final nine-digit number sequence is successfully reproduced. Participants receive two points for each successful digit sequence reproduction if correct on the first attempt, or one point if correct on the second attempt. Successful reproduction of all digit sequences results in a maximum score of 16.

In the Coding task, participants are given a key in which simple, unique geometric shapes are each paired with a digit between 1 and 9. Below the key, the same geometric symbols are presented in a random order with empty boxes underneath each symbol. Participants are required to rapidly fill in as many of the boxes as they can with the digits corresponding to

each unique geometric shape, without skipping any. The time allotment is 90 sec. The score is reported as the number of correctly reproduced pairings. Successful completion of all pairings results in a maximum score of 89.

The RBANS was selected for use in this study as it contains two equivalent versions (A and B) and could, therefore, control for content practice effects. The different test versions were counterbalanced between the two experimental conditions.

Mattis Dementia Rating Scale (DRS)—This scale (Mattis, Jurica, & Leitten, 2002) is commonly used to measure the cognitive status of older adults. Subscales examine attention (e.g., counting targets in an array of distractors), memory (orientation, recall/recognition of sentences, words, and drawings), initiation and maintenance of verbal and motor responses (e.g., grocery store list generation, alternating hand movements), conceptualization (similarities/differences), and construction (design copying). Individual points are assigned to the subscales, with higher points indicating better performance.

In the current study, patients and controls were administered the Dementia Rating Scale between the two experimental conditions. Neither group had previously received this measure as part of their workup for mild cognitive impairment or classification as a control. The first item of the attentional subscale contains a Digit Span task, which was also used as one of the outcome measures of the experimental conditions. Therefore, this item was not administered as part of the Dementia Rating Scale and total scores were prorated.

Procedure

Music was played for participants via headphones connected to a computer. Volume was adjusted for comfort. The musical piece selected was the “Spring” movement of *Four Seasons* by Vivaldi (1990). This piece was selected as previous researchers have reported its enhancing effect on cognitive performance (Foster & Valentine, 1998, 2001; Thompson, *et al.*, 2005; Irish, *et al.*, 2006).

After each condition (music and silence), participants completed the Attentional Index of the RBANS, consisting of the Digit Span and Coding subtests. The order in which the participants were presented with each condition was counterbalanced. An assistant began and ended the experimental conditions, while the experimenter waited outside the testing room so the experimenter would be blind to which condition the participant had been exposed.

The Dementia Rating Scale was administered between the two trial conditions as a battery of cognitively demanding tasks to reduce practice effects and further assess cognitive performance. Administration takes approximately 20 to 30 min. To reduce fatigue effects, the battery was ended early if participants could not complete the test within this time frame and the second trial condition was administered. Only one patient was unable to complete the full Dementia Rating Scale during the allotted time. (Patient statistics for all subscales besides the Construction subscale are, therefore, reported based on a sample size of $n = 11$.) After the completion of the second trial condition, all participants were given a brief questionnaire assessing their past and present extent of musical experience and exposure. Participants were then debriefed as to the study’s purpose. The entire procedure took approximately 60 min.

Results

Digit Span

Table 1 shows the performance of Controls versus Patients with Mild Cognitive Impairment on the Digit Span task. A repeated-measures analysis of variance on the maximum number of points received, with group (Controls versus Patients with Mild Cognitive Impairment) as the between-subject factor and condition (Music versus Silence) as the within-subject factor, showed no significant main effect for group ($F_{1,22} = .002, p = .97, \Delta = .04$). Performance of Controls was comparable to that of the Patients with Mild Cognitive Impairment across conditions ($M = 10.9, SE = .63$ and $M = 10.9, SE = .71$, respectively). There was no significant main effect of condition (Music and Silence) on performance ($F_{1,22} = .55, p = .47, \Delta = -0.46$). Overall performance was similar in the Music versus Silence conditions ($M = 10.7, SE = .50$ and $M = 11.1, SE = .60$, respectively). No interaction between subject group and condition was observed ($F_{1,22} = .04, p = .84, \Delta = .26$).

No significant main effect of music order (Music then Silence versus Silence then Music) was found for Digit Span ($F_{1,22} = 1.41, p = .25, \Delta = -.10$). Similarly, no main effect of test order (Version A then B versus Version B then A) was observed ($F_{1,22} = .04, p = .84, \Delta = .19$). Lastly, there was no evidence of either a practice or fatigue effect as performance on the first condition, regardless of test version, did not differ significantly from the second condition ($t_{23} = .76, p = .46$, two-tailed).

Coding

Table 1 shows the performance of Controls versus Patients with Mild Cognitive Impairment on the Coding task. A repeated-measures analysis of variance on the number of correctly transcribed symbols, with group (Control versus Patients with Mild Cognitive Impairment) as the between-subject factor and condition (Music versus Silence) as the within subject factor, showed a significant main effect for subject group ($F_{1,22} = 22.67, p < .001, \Delta = 14.0$). Control participants outperformed Patients with Mild Cognitive Impairment on this task ($M = 45.9, SE = 2.1$ and $M = 31.9, SE = 2.1$, respectively). No significant main effect of experimental condition (Music versus Silence) on performance ($F_{1,22} = .10, p = .75, \Delta = .29$) was observed ($M = 39.0, SE = 2.2$ and $M = 38.8, SE = 2.0$, respectively). The interaction between subject group and condition was not significant ($F_{1,22} = .60, p = .45, \Delta = .58$).

No significant main effect of music order (Music then Silence versus Silence then Music) was found for Coding ($F_{1,22} = .03, p = .87, \Delta = -.70$) and no main effect of test order (Version A then B versus Version B then A) was observed ($F_{1,22} = .37, p = .55, \Delta = -2.54$). Finally, there was no evidence of either a practice or fatigue effect as performance on the first condition, regardless of test version, did not differ significantly from the second condition ($t_{23} = -.32, p = .75$, two-tailed).

Repeated Measures Analysis of Covariance

Given the significant difference in age between the Controls and Patients, the above analyses for Digit Span and Coding were repeated, with age as a covariate. Results of all the previous analyses were replicated. Repeated measures analyses of covariance showed that controlling for age did not yield in a significant interaction between music condition and subject group for either Digit Span ($p = .3$) or Coding ($p = .6$).

Qualitative Analysis

The data were examined qualitatively to assess whether there was any improvement, regardless of the magnitude of the change, on the Digit Span and the Coding Tasks for the Patients and Controls after listening to music as compared to their performance in the

Silence condition. This analysis showed that only three of the 12 Patients and four of the 12 Controls performed better on Digit Span after listening to music, Fisher's Exact $p > .99$. This is similar to the pattern on Coding, where only five Patients and six Controls performed better in the music condition, (Fisher's Exact $p > .99$). Thus, a consistent benefit of music on cognitive performance was not observed for either group.

Dementia Rating Scale

Table 2 shows the performance of the Controls and Patients on the Mattis Dementia Rating Scale. A main effect of subject group was observed for the Total score ($F_{1,21} = 16.1, p = .0006, \Delta = 8.0$) with Controls outperforming Patients. Performance of Controls on the Memory subscale was significantly higher than that of the Patients ($F_{1,21} = 11.47, p = .003, \Delta = 3.7$). Based on age-corrected norms available in the test manual, half of the patients had moderate-severe impairments on the Memory subscale.

Scores on the Attention subscale fell short of significance ($F_{1,21} = 3.60, p = .07, \Delta = .90$), with performance of Controls higher than that of the Patients. No significant differences between subject groups were observed for the other subscales of the Dementia Rating Scale involving Initiation/Perseveration ($F_{1,21} = 1.94, p = .18, \Delta = 1.5$), Construction ($F_{1,21} = .38, p = .54, \Delta = .1$), and Conceptualization ($F_{1,21} = 1.44, p = .24, \Delta = .7$).

Musical Background and Listening Habits

Fisher's Exact tests were employed to assess whether the two groups differed in their musical backgrounds or weekly listening habits based on self-reported answers on a brief questionnaire at the conclusion of the experiment. No significant differences were observed. The majority of participants reported that they listened to music up to 10 hrs a week (nine Patients with Mild Cognitive Impairment and eight Controls).

Discussion

Our results do not support an enhancing effect of music on attention in either mild cognitive impairment patients or cognitively normal older adults. Various factors may have contributed to these null findings. One possibility is that our study lacked statistical power to detect true differences that may have existed. In order to circumvent the potential contribution of low power as an explanation, we performed qualitative analyses in which patterns of improvement, regardless of the magnitude of change, were examined. These nonparametric analyses did not reveal consistent benefits of music on the cognitive performance of either the patients or the controls. Another possible explanation for a lack of differences between groups concerns the effects of fatigue caused by participation in a one hour testing session. However, there were no effects of performance dependent on whether tasks were performed at the beginning versus the end of the session. The nature of the study sample could explain the lack of improvement in attention observed after the music condition in this study. The results indicate that, although the group with mild cognitive impairment showed significant memory impairments, their scores on the Dementia Rating Scale Attention subscale fell short of differing from those of the control group, and their performance on the Digit Span subtest was comparable. This suggests that our patient group may not have had sufficiently severe impairments in attentional abilities to benefit from an enhancement through music listening. Future studies might enroll patients with mild cognitive impairment specifically presenting with executive function and attentional deficits to better assess whether task performance can be enhanced through music when such deficits are present. In addition, inclusion of a group with more severe attentional problems, such as patients with Alzheimer's disease, might provide valuable comparisons.

The current findings are noteworthy in light of previous studies which have suggested an improvement on different measures of attention as a result of listening to music (Thompson, *et al.*, 2005; Ho, *et al.*, 2007; Mammarella, *et al.*, 2007; Jefferies, Smilek, Eich, & Enns, 2008). A key difference between this study and those which have supported an enhancing effect of music on attentional abilities involves the timing of the stimulus presentation. In the studies cited above, music was played *during* task performance while in the current study, music was played *prior* to the assessment of attentional abilities. A study by Steele, Ball, and Runk (1997) corroborates the idea that an enhancing effect of music on attentional tasks may only be observed when music is played concurrently with task completion, as performance on a similar attentional task (backward digit span) was not enhanced when music was played prior to task performance. It has been suggested that the improvement in performance when music is played concurrently with cognitive testing is due to reduced distraction, allowing more attention to be focused on the task (Foster & Valentine, 2001). If this hypothesis is accurate, it might account for the lack of improvement in task performance in this experiment, as the distraction masking effect of music would be expected to end when the music stopped. Replicating the current study while manipulating the presentation time of music would be useful in further addressing this issue. This potential distracting effect of music may be limited to certain types of tasks, such as those measuring attention, as multiple studies have found enhancing effects of music on cognitive tasks administered after the presentation of music (e.g., Rauscher, *et al.*, 1993; 1995; Roth & Smith, 2008). Alternate explanations, such as the arousal hypothesis, might account for the findings in these studies. Measuring performance over time could address this theory as heightened arousal in response to music would be expected to decline with time.

Another factor that could have influenced the findings of this study was the implementation of a blind experimental design. Playing music before testing cognitive performance provided an advantage in that it enabled the experimenter to leave the room while a study assistant administered the testing conditions. In this way, the experimenter remained naive to the experimental condition while administering the cognitive testing, thereby eliminating the potential influence of experimenter expectancy on performance. Previous studies of the short-term effect of music on cognitive performance have not reported using a blinded design, although other controls have been used.

In conclusion, this study did not reproduce previous findings of an enhancing effect of music listening on cognitive performance in older adults. The impact of music on cognitive performance is an issue that is still far from being solved due to many intervening variables. Further research is necessary to understand more fully the effect of music on attentional processes and how these attentional processes can be modulated in older adults.

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Table 1

Performance Means and Standard Errors on the Digit Span and Coding Tasks in the Music and Silence Conditions for Controls (n=12) and Patients with Mild Cognitive Impairment (n=12).

Controls		<i>M</i>	<i>SE</i>	<i>MCI</i>		<i>M</i>	<i>SE</i>
Digit Span				Digit Span			
Condition	Music	10.8	.74	Condition	Music	10.6	.71
	Silence	11.1	.87		Silence	11.2	.87
Coding				Coding			
Condition	Music	46.4	2.1	Condition	Music	31.7	2.5
	Silence	45.4	2.3		Silence	32.1	1.9

Table 2

Performance Means and Standard Errors on the Mattis Dementia Rating Scale for Normal Controls (n=12) and Patients with Mild Cognitive Impairment (n=11).

Measure	Controls		MCI	
	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>
Total Score (out of 126)	122.4	.8	114.4	1.9
Attention (out of 19)	18.8	.1	17.9	.5
Initiation/Perseveration (out of 37)	36.0	.7	34.5	.9
Conceptualization (out of 39)	38.1	.4	37.4	.5
Construction (out of 6)	5.8	.2	5.7	.3
Memory (out of 25)	23.9	.3	20.2	1.1