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Musical training improves memory for instrumental music, but not vocal music or words

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Abstract
In previous research, there exists some debate about the effects of musical training on memory for verbal material. The current research examines this relationship, while also considering musical training effects on memory for musical excerpts. Twenty individuals with musical training were tested and their results were compared to 20 age-matched individuals with no musical experience. Musically trained individuals demonstrated a higher level of memory for classical musical excerpts, with no significant differences for popular musical excerpts or for words. These findings are in support of previous research showing that while music and words overlap in terms of their processing in the brain, there is not necessarily a facilitative effect between training in one domain and performance in the other.

Keywords
Memory, transfer effects, training, short term memory, cognition

Language and music are forms of human communication that are closely related in terms of cognitive abilities (Schellenberg & Weiss, 2013), have interactions in their neural processing (Patel, 2003), and may even have evolutionary roots as a common vocal utterance which was later differentiated into multiple streams (Brown, 2000). In terms of linguistic abilities, there is a large corpus of evidence focusing on the differences between individuals with or without musical training on language tasks (e.g. Moreno, Marques, Santos, Santos, Castro, & Besson, 2009; Tierney & Kraus, 2013), as well as potential for facilitative effects of music presented simultaneously during a verbal memory task (e.g. Jancke, Brugger, Brummer, Scherrer, &

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Alahmadi, 2014; Kang & Williamson, 2013). Many of the researchers focusing on musical training and its effect on memory recruit participant groups that already have had (or not had) musical training earlier in their lives. In one example of this thread of research, Chan, Ho, and Cheung (1998) compared musicians with non-musicians on a verbal learning task and found that musicians had significantly higher recall scores than non-musicians. In a broader study, Brandler and Rammsayer (2003) tested musicians and non-musicians on various memory types, finding that verbal memory scores were significantly higher in musicians than non-musicians, while numerical and spatial memory were nearly identical across the two groups. Ho, Cheung, and Chan (2003) substantiate Brandler and Rammsayer's (2003) results with their findings that musical training improves verbal memory but has no effect on visual memory. These findings suggest that the facilitative effect of musical training is specific to verbal memory, rather than being a more general memory advantage.

Given these findings of memory facilitation stemming from musical training, it is of interest to consider whether musical experience provides improvements in verbal memory, and specifically whether music can be used as a memory aid for words, by using them as lyrics. To this end, Racette and Peretz (2007) studied the effectiveness of music as a memory aid for words, and found that when the song being used was novel, there was no advantage to using music. In fact, learning was more effective when words were learned in the absence of music. Additionally, Peterson and Thaut (2007) tested participants' memory for words that were spoken and for words that were sung, finding that there was no behavioural advantage for singing over speaking, although there was an increase in frontal EEG coherence, which has been found to be an index of verbal learning (e.g. Johnson, Saykin, Flashman, McAllister, & Sparling, 2001). Studies such as these suggest an alternative view to the research discussed above (e.g. Ho et al., 2003) – that musical melody and words are processed separately from one another in the brain. If it is the case that music and words are processed separately, then we also would not expect transfer from musical training to increased memory for words (although this study did not consider the degree to which musicians may have been engaging in "verbal training" experiences, such as memorization of acting scripts). Experience with music through formal training would improve an individual's ability to process musical material and should also increase memory for musical material, but there would be no effect on verbal memory as was shown by Chan, Ho, and Cheung (2008). More recently, Taylor and Dewhurst (2017) provided evidence that differs from that produced by Racette and Peretz (2007) by testing participants with and without musical training on their ability to recall words that were high in auditory imagery, visual imagery, were tactile, or were abstract. They found that musically trained individuals had higher levels of recall overall than those without musical training, and that there was no interaction between level of training and type of word. There is an additional possibility, which is that linguistic and musical materials use similar syntactic structures, despite the differences in the material represented within these structures. Patel's Shared Syntactic Integration Resource Hypothesis (Patel, Gibson, Ratner, Besson, & Holcomb, 1998; Patel, 2003) posits that the brain uses the same neural resources to process the syntactic information present in both language and music. Thus, musical training would lead to an improvement in those shared neural resources, improving both musical and linguistic abilities.

With the existence of multiple perspectives in previous research, the present research considers additional factors in the memory of musicians and of non-musicians. Specifically, we examine the respective levels of performance of these two groups of individuals on memory for words and music in isolation from one another and in combination, which will provide insight into the interaction between general and specific forms of memory. Participants with and without musical training were presented with samples of words, pop music (with words and music), and classical music (music only). Based on previous findings from Taylor and Dewhurst (2017), we might expect to find higher levels of recall for musicians than non-musicians, across all three stimulus types, which would provide evidence for the close relationship between verbal and musical memory, and for the generality of memory across the two stimulus types. However, the findings of Racette and Peretz (2007) suggest higher levels of recall for musical material in musicians, but no increase in verbal memory. Should we observe this pattern of results, it would suggest that, while music and words may be related evolutionarily (Brown, 2000), memory systems for the two domains do not interact with one another. As such, the findings of the current research will assist in differentiating between theoretical perspectives wherein musical and verbal memory systems are inter-related with one another (as per Taylor & Dewhurst, 2017), or relatively isolated from one another (as per Racette & Peretz, 2007). We expect to find support for a close relationship between musical training and memory for both words and music, providing evidence for related memory systems and contributing to the corpus of evidence (e.g. Brown, 2000; Chan et al., 1998; Ho et al., 2003) showing that music and language are inextricably linked.

Method

Participants

Musicians group. Musicians were recruited from the student population at the Royal Conservatory of Music's Glenn Gould School, as well as from the Mount Allison University Conservatory of Music. These participants were compensated with payment of $8 for their participation. The mean age of the 20 participants in the musicians group was 22.7 years ($SD = 8.5$), and the group consisted of 4 males and 16 females. They had an average of 12.2 years of musical training ($SD = 1.8$). They listened to 20.2 hours of music a week ($SD = 17.8$) and read for 8.7 hours per week ($SD = 7.3$), on average.

Non-musicians group. Non-musicians were recruited from introductory psychology classes at Ryerson University. These participants were compensated for their time by means of partial class credit for experimental participation. The mean age of the 20 participants in the non-musicians group was 22.2 years ($SD = 8.7$), and the group consisted of 5 males and 15 females. They had an average of 0.6 years of musical training ($SD = 0.8$). They listened to 12.1 hours of music a week ($SD = 8.2$) and read for 8.8 hours per week ($SD = 7.6$), on average.

Group comparisons. The two experimental groups were matched for age, $t(38) = .17$, $p = .87$, and gender, $t(38) = .37$, $p = .71$. In order to establish that our groups were different from one another in terms of musical experience, recruitment criteria required that participants in the musician group had a minimum of eight years of formal musical training, and that those in the non-musician group had a maximum of two years. Evaluating the information provided by participants showed that there was indeed a significant difference in the amount of musical training, $t(38) = 13.87$, $p < .001$, between the two groups. Interestingly, there was no significant difference between groups in terms of amount of time spent listening to music, $t(38) = 1.86$, $p = .07$, or the amount of time spent reading, $t(38) = .11$, $p = .92$. While this lack of significant difference is clear for time spent reading ($p = .92$), the difference in amount of time

Table 1. Stimuli used for verbal memory tests.

Words	Syllables (number)
bell	1
colour	2
house	1
drum	1
moon	1
turkey	2
school	1
nose	1
farmer	2
hat	1
garden	2
coffee	2
river	2
parent	2
curtain	2
M	*1.53*
SD	*.52*

listening to music does approach standard levels of significance ($p = .07$), and as such we must consider that there may be some effect of familiarity with music.

Materials

The experiment used three tests of memory which were designed to be analogous to one another, with one testing musical memory, one testing verbal memory, and one testing a combination of both types of memory. The verbal test used was an existing psychological evaluation tool which has long been regarded as a reliable measure. The musical tests were designed to be as similar as possible to the verbal test. These tests were presented to participants automatically by a computer program. Detailed descriptions of the presentation apparatus and testing materials follow.

Computer program. Auditory material was presented binaurally through Logitech ML235 headphones, and was played at a standardised, clearly audible volume. Experimental input was given verbally and captured by a microphone. The experimental programme was designed and run in Microsoft Office PowerPoint 2007. The programme consisted of a PowerPoint slide show of sixteen slides, all of which had a plain black background.

Verbal memory test. The verbal memory portion of the experiment used the Rey Auditory Verbal Memory Test (RAVLT), which was initially developed in French by clinical psychologist André Rey (1958). The test involves the presentation of fifteen commonly used nouns (see Table 1) at a rate of one word per second, followed by free recall of words by the participant. The test is traditionally administered orally with the investigator reading aloud a set of instructions and then reading out the list of words. During the free recall period, the investigator writes down the participant's responses. In the interests of standardisation and accuracy, it was decided that the

Table 2. Pop music samples.

Song	Artist	Length (s)	Notes (number)	Words (number)
Grenade	Bruno Mars	2.4	7	7
Hello	Adele	3.8	7	5
Happy	Pharrell Williams	2.2	5	3
All about that bass	Meghan Trainor	1.4	6	6
Shake it off	Taylor Swift	2.3	6	6
Wrecking ball	Miley Cyrus	2.6	8	7
Just give me a reason	Pink	2.0	6	5
Call me maybe	Carly Rae Jepsen	1.4	5	4
Sexy and I know it	LMFAO	1.8	7	6
Moves like Jagger	Maroon 5	2.1	7	6
We found love	Rihanna	2.7	8	7
Last Friday night	Katy Perry	1.9	4	3
Stronger	Kelly Clarkson	2.2	9	7
Timber	Pit Bull f. Ke$ha	2.3	5	4
Fancy	Iggy Azalea	2.3	4	3
M		*2.23*	*6.27*	*5.27*
SD		*.57*	*1.49*	*1.53*

stimuli should be presented from a pre-recorded sound file on a computer and that responses should be recorded by a sound recorder, to be transcribed at a later time.

Musical memory tests. The musical memory tests were designed as musical analogues to the RAVLT used to test participants' verbal memories. Musical memory tests were created that included fifteen motifs to be remembered, serving as analogues to words. The pop music test involved recent pop music that had been ranked at Number 1 on the Billboard chart during 2014. An additional test involved famous classical motifs chosen from the Essential 100 Classical Pieces compilation album (Telos, 2011). The pop music was presented with lyrics and music, while the classical music was presented instrumentally only, even if there were lyrics in the original piece (e.g. Schubert's "Die Forelle"). Segments were chosen as the most iconic portion of a piece of music – oftentimes the first phrase, or the first phrase of the chorus of a piece. The pop music motifs are listed in Table 2, and were an average of 2.23 seconds long, 6.27 notes, and 5.27 words. Classical motifs (Table 3) were an average of 3.03 seconds long, with an average of 9.53 notes.

Procedure

There were three potential orders of words and three orders of each set of musical excerpts. The order in which participants did the three tests was counterbalanced. Participants controlled stimulus presentation by clicking a speaker icon on the screen. The participant was given verbal instructions to listen to the words/music and try to remember as many as possible so that they could recall them later. The words/music were then presented with one second between each stimulus, after which the participant had a period in which they recalled as many words as they could remember and said them back (or sang back as many of the motifs from the list as they could recall). Once they could not recall any more words/

Table 3. Classical music samples.

Song	Artist	Length (s)	Notes (number)
Morning Mood	Edvard Grieg	3.6	12
Symphony No. 5	Ludwig van Beethoven	1.5	4
Four Seasons: Spring	Antonio Vivaldi	2.8	7
Die Walküre	Richard Wagner	3.0	10
Symphony No. 9	Antonín Dvořák	3.4	3
Hungarian Dance No. 5	Johannes Brahms	3.6	8
Für Elise	Ludwig van Beethoven	2.4	9
Symphony No. 9	Ludwig van Beethoven	3.9	15
Serenade No. 13	W. A. Mozart	2.8	9
Sonata KV 331	W. A. Mozart	1.8	10
Hall of the Mountain King	Edvard Grieg	3.1	13
William Tell Overture	Gioachino Rossini	2.6	19
Hallelujah Chorus	G. F. Handel	3.8	8
Die Forelle	Franz Schubert	3.4	7
Toccata and Fugue	Johann Sebastian Bach	3.7	9
M		*3.03*	*9.53*
SD		*.72*	*4.05*

motifs, they ended the recall period and proceeded to the second trial. The instructions were given again, and the same words (or motifs) in identical order were presented a total of five times to each participant. After each of these presentations, a period of free recall took place during which the participant recalled as many words (or motifs) as possible. During this period, participants would say or sing back as many of the stimuli as they could recall, including those they had recalled on previous trials. When they could not recall any more stimuli, they advanced the experimental programme to the next stage. Once the fifth free recall period had concluded, that test was complete.

Once the experimental programme was complete, before leaving, the participant was asked to complete a questionnaire, which included questions regarding the participant's level of musical training, musical listening and reading habits, and familiarity with any of the musical excerpts employed in the experiment. Total time of testing was approximately 30 minutes.

Results

Responses were scored for accuracy, resulting in a score out of a maximum of 15 points for each trial. Accuracy was determined by listening to each response, and was scored as correct if the word/motif was recognizable to the evaluator (that is – verbatim reproduction of the melody/words was not necessary). Scores were converted to proportion correct for further analysis. Comparing the length of music samples, we found that the classical musical motifs were significantly longer than the pop music motifs for both elapsed time, $t(28) = 3.36$, $p = .002$, and number of notes, $t(28) = 2.93$, $p = .007$.

The data were submitted to a 2 (group: musicians, non-musicians) x 3 (type: words, pop music, classical music) x 5 (recall attempt: 1, 2, 3, 4, 5) mixed model ANOVA, the full results of which are displayed in Table 4. There was a main effect of group (see Figure 1), $F(1, 38) = 28.663$, $p < .001$, $\eta_p^2 = .43$, with musicians exhibiting significantly higher recall than non-musicians, as well as a main effect of stimulus type, $F(2, 76) = 74.273$, $p < .001$, $\eta_p^2 = .66$, with

Table 4. Results of 2 x 3 x 5 ANOVA on recall scores.

Measure	*df*	MSE	*F*	*p*	η_p^2
Group	1, 38	.102	28.663	<.001	.430
Type	2, 76	.053	74.273	<.001	.662
Attempt	4, 152	.005	425.303	<.001	.918
Group x Type	2, 76	.053	6.477	.003	.146
Group x Attempt	4, 152	.005	0.841	.501	.022
Type x Attempt	8, 304	.004	9.545	<.001	.201
Group x Type x Attempt	8, 304	.004	3.831	<.001	.092

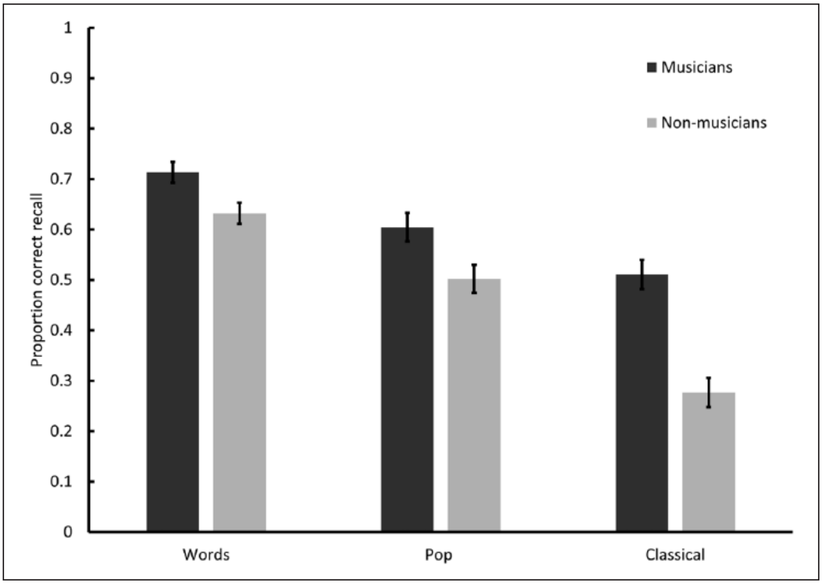

Figure 1. Proportion correct for musicians and non-musicians on recall for words, popular music, and classical music. Error bars represent standard error.

memory for words exhibiting a higher level of recall than memory for pop music, which in turn was higher than memory for classical music. A significant interaction between stimulus type and group, $F(2, 76) = 6.477$, $p = .003$, $\eta_p^2 = .15$, was probed by means of a Tukey's HSD post-hoc test ($p < .05$). The Tukey's HSD revealed that recall was significantly better for musicians than non-musicians for classical music only, although there was a trend towards significance for popular music ($p = .07$), and that there was no significant difference between the two groups in recall for words.

A significant main effect was found for the factor of recall attempt, $F(4, 152) = 425.303$, $p < .001$, $\eta_p^2 = .92$, along with a significant interaction between stimulus type and recall attempt, $F(8, 304) = 9.545$, $p < .001$, $\eta_p^2 = .20$. Follow-up testing with Tukey's HSD showed that the differences between words, pop music, and classical music were also significant for all pair-wise comparisons at each trial number. Finally, a three-way interaction between group, stimulus type, and recall attempt was significant, $F(8, 304) = 3.831$, $p < .001$, $\eta_p^2 = .09$, and is displayed in Figure 2. Tukey's HSD did not provide any additional information beyond what was already

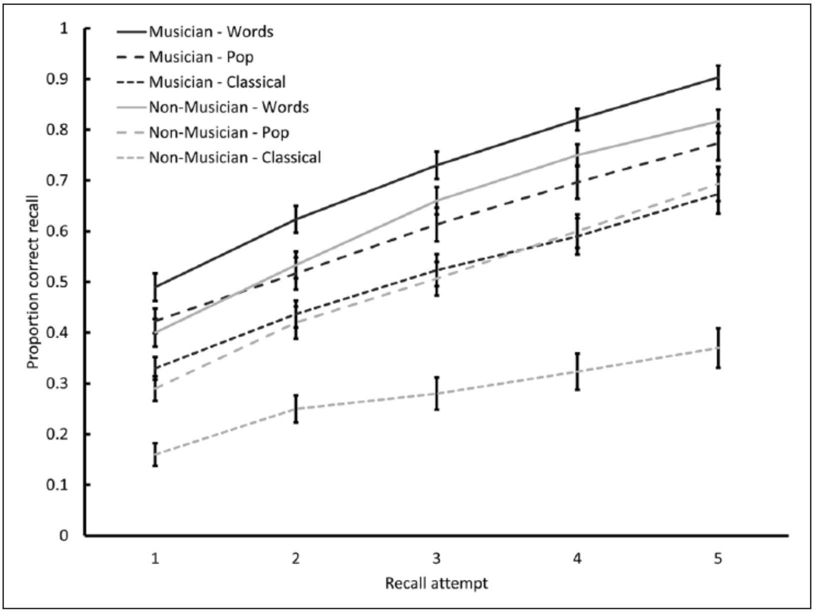

Figure 2. Proportion correct for each combination of group (musicians, non-musicians), stimulus type (words, popular music, classical music), and trial number (1–5). Error bars represent standard error.

known from the lower order effects and interactions. Performance increased for each trial number for each condition as per the main effect of recall attempt discussed above, but this did not modulate by any of the conditions. As such, it appears the interaction only represents the two-way interaction between stimulus type and participant group, with the combination of non-musicians and classical music showing the worst performance.

After completion of the experimental task, participants were asked to identify how many of the musical excerpts they had heard before, based on their memory from having completed the task. Only 31 of 40 participants responded to this question, which was part of a larger survey including musical experience, which resulted in the reduced degrees of freedom for the *t*-test. There was no significant difference between groups in familiarity with the popular music (musicians' $M = 13.7$, $SD = 2.5$; non-musicians' $M = 13.6$, $SD = 2.6$), $t(29) = .27$, $p = .79$, or in familiarity with the classical music (musicians' $M = 12.3$, $SD = 2.6$; non-musicians' $M = 12.1$, $SD = 4.1$), $t\,(29) = .28$, $ps = .78$.

Discussion

In summarising the results, we see that musically trained individuals tend to have a greater level of recall than non-musicians for classical musical motifs, while there was no significant advantage in recall for words or popular musical motifs. We also find that while both groups show improvement over the course of the five recall trials, there is no difference in the degree of improvement between the two groups. It is possible that the differences found are at least partially caused by musical listening habits, as the difference in amount of time listening to music between the two groups trends towards significance ($p = .07$). That being said, there was no difference in participants' familiarity with the specific excerpts being used ($ps > .78$), so the important difference is strictly in the volume of music listening that musicians engage in beyond non-musicians. An important part of musical training involves listening to music critically for the purposes of analysis, and as such we do not claim to be separating effects of musical training and effects of listening, but rather showing that musical training overall contributes to increasing memory.

In comparing our results with the findings in previous research, we find similarity with the findings of Racette and Peretz (2007) – musical training leads to an increase in memory for classical musical motifs – but no difference for non-musical stimuli such as words. We also found no significant advantage for musicians in remembering popular musical motifs when words and music were presented simultaneously, which aligns with the findings of Peterson and Thaut (2007). These results suggest that memory systems for these musical and verbal auditory stimuli are separate from one another (as per Racette & Peretz, 2007), given that musical training was associated with classical musical memory performance, and that there was no effect of training on verbal memory performance. However, there appears to be an additional factor driving the results, since the advantage for musically trained participants was exclusive to classical musical motifs and not found for popular music. Two possible factors could be leading to this finding. First, it is possible that experience with classical music through their training allowed them to perform well on the memory test (although there was no significant difference in familiarity with motifs). Alternately, popular musical motifs may have been easier to remember in general than classical motifs, and this ease of memory could have led to a lack of differentiation between groups. This explanation is supported by the data (shown in Figure 1), wherein classical memory performance was lower for both groups of participants, and also by the fact that classical musical motifs were shown to be significantly longer in duration and number of notes than the popular motifs (see Method section).

The findings from the present research contribute to an ongoing topic of research into the contributions of formal musical training, especially during childhood and adolescence, to musical and non-musical abilities during adulthood. The findings also do not strictly support other previous research showing advantages in verbal memory (Brandler & Rammsayer, 2003; Ho, Chan, & Cheung, 1998), although we also do not show opposite findings to those found by Taylor and Dewhurst (2017). Given these two auditory processes emerge at around the same time in development, and that there is similar evidence for the existence of critical periods in both, it is sensible to consider whether there is a developmental interaction between them. Kraus and Banai (2007) discuss malleability between auditory processing developments and discuss their interaction as having the potential to complement one another. However, other research by Yang, Ma, Gong, and Yao (2014) shows that musical expertise leads to increases in musical memory (as well as second language learning), but not to first language learning. They also suggest that there is a moderating effect of the amount of practice taking place during training on the increases in memory that are achieved – that is, it may not be training in and of itself, but rather the amount of engagement with the material that leads to memory improvement. The results of the current study indicate that musical training leads to increases in musical memory, but not in verbal memory. Based on the previous research looking at critical periods in language and music (e.g. Johnson & Newport, 1989; Trainor, 2005), it is reasonable to expect some interaction between the development of these processes, and as such it would be of interest for future research to examine the ages at which participants received their training – with the working hypothesis that people who were trained early in childhood would exhibit greater memory performance than those who were trained later in life. For the time being, however, the results show that musical training improves an individual's musical memory, but not their verbal memory.

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