Investigating the influence of music training on verbal memory

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Abstract

Previous research has shown that musical training is associated with enhanced verbal memory. The current study investigated the generality of this association by presenting undergraduates who had received musical training (n = 20) and undergraduates with no formal music training (n = 20) with four types of word list; high visual imagery, high auditory imagery, high tactile imagery, and abstract. Those who had received music training showed enhanced memory for all word lists, suggesting that music training leads to a general enhancement in verbal memory that is not restricted to specific types of words (e.g., those invoking auditory imagery). The findings support previous research in showing that music training enhances cognitive skills beyond those that are specific to the domain of music. The possible cognitive and neural factors underpinning this effect are discussed.

Keywords

verbal memory, music training, expertise, cognition, short-term memory

Music training results in the development of many skills, such as reading musical notation, improvisation, and fine motor movements (Schlaug, Norton, & Overy, 2005). As would be expected, the cognitive processes underlying these skills improve with experience. For example, the number of errors made when learning a novel piece decreases as years of experience increase (Drake & Palmer, 2000). Music training also been associated with enhanced memory for sequences of musical rhythms (Schaal, Banissy, & Lange, 2015) and

for temporal intervals (Aagten-Murply, Cappagli, & Burr, 2014). Research has also revealed that music training is associated with enhanced performance on a variety of non-musical cognitive and perceptual tasks. For example, beneficial effects of musical training have been observed in academic performance and IQ scores (Schellenberg, 2006), mathematical performance (Vaughn, 2000), and attention (Xang, Ossher, and Reuter-Lorenz, 2015). Another important non-musical skill that has been found to be improved in individuals with music training is verbal memory (e.g., Jakobson, Lewycky, Kilgour & Stoesz, 2008; Ho, Cheung & Chan, 2003). In the current study we investigated the generality of the verbal memory enhancement resulting from musical training.

An early study comparing verbal memory in musicians and non-musicians was reported by Chan, Ho and Cheung (1998). In this study, the musicians were all adults who had received at least six years of training before the age of 12, and the non-musicians had received no music training. The task required recall of a 16-word list, which was presented orally three times to each participant. Visual memory was also investigated by asking participants to draw simple figures from memory. It was found that music training was associated with improved verbal but not visual memory, suggesting that music training during childhood may have long term beneficial effects on verbal memory. However, caution must be exercised in interpreting these results as those individuals who chose to engage in music training may have been of a certain personality type or had other motivating factors. In a follow-up study, Ho, Cheung and Chan (2003) attempted to resolve this issue by testing children from a single school who had received between one and five years of music training (at least one hour a week). The children were tested at different stages of music training on verbal and visual memory measures. The researchers also followed up the children one year after the experiment. Again, it was found that music training improved verbal memory for orally presented word lists, but did not improve visual memory. The authors concluded that

music training during childhood results in enhanced verbal memory due to structural and functional changes in the brain.

Further evidence for enhanced verbal memory among musically trained individuals was provided by Franklin, Sledge-Moore, Yip, Jonides, Rattray, and Moher (2008), who compared the performance of trained musicians and non-musicians on an intelligence test, a verbal learning test, and a verbal working memory test. It was found that the musicians had superior verbal long-term memory and verbal working memory. Franklin et al. also observed that articulatory suppression eliminated the superior verbal memory in musicians, suggesting that musicians have an enhanced verbal rehearsal mechanism. A number of studies have shown that musicians also have enhanced memory for perceptual stimuli, particularly in the auditory modality. For example, Cohen, Evans, Horowitz and Wolfe (2011) found that musicians have superior recognition memory for music, speech and environmental sounds, while Aleman, Nieuwenstein, Boecker and de Haan (2000) found that musicians show enhanced performance when comparing pitches of notes and also when comparing the characteristics of everyday sounds.

The enhanced memory for auditory stimuli is intuitive given the auditory nature of music. However, recent studies have also found that the superior memory performance in musicians extends to visual tasks. For example, Jakobson et al. (2008) tested 15 trained musicians and 21 individuals with little or no history of music training. The musicians showed superior immediate and delayed recall of written word lists and were more likely to use a semantic clustering strategy to aid memory. The musicians also had superior recall of visual designs. Jakobson et al. concluded that music training is associated with improvement of both verbal and visual memory, which they attributed to enhanced encoding processes. Sluming et al. (2005) measured visuo-spatial memory and IQ and found enhanced visuo-spatial memory in male musicians only. There is also evidence for superior tactile

performance in musicians. Ragert, Schmidt, Altenmueller and Dinse (2004) found that pianists show superior performance on the simultaneous two-point discrimination paradigm (in which participants were required to judge whether they had felt one or two needles touching their skin). Ragert et al. concluded that there is a direct link between tactile acuity and frequency of piano practising.

The aim of the proposed research was to investigate whether the effects of music training on verbal recall is affected by the nature of the words that participants are instructed to remember. Four types of word lists were presented to musicians and non-musicians; abstract words and words high in auditory, visual, or tactile imagery. The use of words representing different modalities follows on from research that has found enhanced perceptual skills in musicians (e.g., Aleman et al., 2000, Cohen et al., 2011). Of particular relevance to the current study is the finding by Aagten-Murphy et al. (2014) that musicians' enhanced ability to reproduce temporal intervals was found in both auditory and visual modalities. In the current study, it was hypothesized that musicians would display superior verbal memory compared to non-musicians. Our main aim was to investigate the generality of this effect. If the effect relies on the enhanced perceptual abilities of musicians then it should be found in the auditory and visual lists and possibly in the tactile list, but not in the abstract list. If, however, it is a general enhancement that does not rely on perceptual processes then the memory enhancement should be observed for all four list types.

Method

Participants

Forty undergraduate students participated in the study, of which 20 were categorised as musicians and 20 as non-musicians. A musician was defined as an individual who currently

practiced a musical instrument at least once a week and had received at least four years of music training. The non-musicians had received no music training. The cohort consisted of 22 males and 18 females, with 11 males and 9 females in both groups. Ages ranged from 19-30. Mean age was 21.50 (*SD* = 2.54) for the musicians and 21.85 (*SD* = 2.98) for the non-musicians. All participants were native English speakers. Participation was voluntary with no reward or payment. Ethical approval for the study was granted by the local ethics committee. A power analysis based on the verbal recall data reported by Franklin et al. (2008) with an effect size of *Cohen's d* = 1.86 and power (1 - β error probability) set to 0.80 indicated that a minimum sample size of 17 per group was sufficient.

Stimuli and design

Four lists of 20 words each were chosen from the MRC Psycholinguistic Database (Wilson, 1988). The visual words were high imagery nouns for which the referents can be easily visualised, such as *desk*. The auditory words were high in auditory imagery and represented sounds such as *crash*. The tactile words described sensations of touch such as *prickly*. The abstract words represented concepts with no physical or perceptual properties, such as *wisdom*. The words used ranged in length from three to eight letters and from one to four syllables. As the frequency with which a word occurs in printed language has been shown to affect its memorability (see Dewhurst, Brand & Sharp, 2004, for a review), the word lists in the current study were matched for frequency of occurrence per million (as measured by Kucera & Francis, 1967). The words were of moderate to high frequency, with means of 28.9 (*SD* = 57.68) for the auditory word list, 29.4 (*SD* = 29.92) for the visual word list, 29.1 (*SD* = 46.57) for the tactile word list and 28.7 (*SD* = 27.63) for the abstract word list. List type was manipulated within groups, such that each participant saw all four lists, and the order of the lists was rotated in a Latin square. The dependent variable was the number of words recalled

from each list.

Procedure

After signing a consent form, participants sat facing the computer. A *PowerPoint* slideshow presentation was used to display the word lists. There was one word per slide, which was positioned in the centre of the slide. The font was Calibri (Body) size 60 and all words were black and written in upper case (see Appendix 1 for the full lists of words). Before each word list an introductory slide was presented, reading 'List (number of list e.g. 1). Press space bar to continue'. The words were presented one at a time for a period of two seconds each, followed directly by the next word. There was an introductory slide preceding each list, announcing which list was next (e.g. 'List 2) and instructing the participant to press the space bar when they were ready to proceed with the list. The participant was not required to press any further keys throughout the experiment. Within each list, the same random order of word presentation was used for each participant. At the end of each list, the slide show automatically paused at the introductory slide for the next list, and participants were asked to count backward in multiples of three from a three digit number specified by the experimenter. After 10 seconds of backward counting, the participant was instructed to recall as many of the words from the previous list as possible, in any order, on the paper in front of them. Participants wrote the recalled words on a response sheet with the headings 'L1', 'L2', 'L3' and 'L4' at equal intervals across the page. Participants were allowed 5 minutes to complete the recall test.

Results

Table 1 shows the mean correct recall scores of musicians and non-musicians for each list type. A preliminary one-way ANOVA with list order treated as a between-groups factor

indicated that the order in which the lists were presented did not affect recall levels, $F < 1$. The data were therefore analyzed using a 2 (group: musicians versus non-musicians) x 4 (list type: visual, auditory, tactile, abstract) mixed ANOVA with repeated measures on the second factor. Alpha was set at .05 for all main effects and interactions, and all pairwise comparisons were Bonferroni-adjusted. There was a significant main effect of group, whereby musicians had higher levels of correct recall overall than non-musicians, $F(1, 38) = 4.48$, $MSE = 15.99$, $p = .041$, $\eta_p^2 = .11$. There was also a significant main effect of list type, $F(3, 114) = 9.37$, $p < .001$, $\eta_p^2 = .20$. Pairwise comparisons revealed that recall of the abstract words was significantly lower than recall of the auditory and tactile words, both *p*s < .001, and lower than recall of visual words to a nonsignificant degree, $p = .058$. Recall scores for the visual, auditory and tactile words did not differ significantly from each other, all *p*s > .97. The interaction between word list type and group was not significant, $F(3, 38) = 1.02$, $p = .385$, $\eta_p^2 = .03$, indicating that the effect of music training was present for all list types.

Discussion

The main finding from the current study is that musicians recalled significantly more words than non-musicians. Of the three modalities represented in the present experiment (auditory, visual and tactile), previous research has most often found that musicians have an advantage in tasks that require auditory perception (e.g., Aleman et al., 2000; Cohen et al., 2011) or visual perception (e.g. Jakobson et al., 2008; Sluming et al., 2005). To the best of our knowledge, only one previous study has found an advantage for musicians in a tactile task (Ragert et al., 2004). The current results extend previous findings by showing that musicians have enhanced memory for words that relate to these three modalities, as well as for abstract words.

Several theories have been proposed to explain superior verbal recall in musicians.

Franklin et al. (2008) speculated that musicians possess an enhanced verbal rehearsal mechanism and found support for this by showing that the advantage was eliminated when verbal rehearsal was prevented by articulatory suppression. Jakobson et al. (2008) suggested that musicians engage in superior encoding strategies, particularly in terms of extracting higher order semantic information, relative to non-musicians. These theories suggest that the locus of the memory advantage is in encoding processes rather than retrieval processes. This is further supported by the finding of Jakobson et al. that retrieval prompts did not enhance the performance of non-musicians relative to musicians. In the present experiment, the scores across the different list types show the same pattern for musicians and non-musicians; the auditory and tactile lists showed the highest recall for both groups, the visual list had slightly (but not significantly) lower scores and the abstract words had significantly lower scores in both groups. The finding from the current study that musicians and non-musicians showed the same profile in their relative recall of the four list types suggests a general encoding advantage that is not limited to specific types of words.

One possible limitation of the current study is that the participants were not tested for general cognitive ability. It is possible that the musicians in the current study had relatively enhanced general cognitive abilities rather than a specific enhancement in verbal memory ability. However, the fact that participants were undergraduate students suggests they were of comparable academic ability and educational attainment. In addition, previous research has indicated that verbal memory in musicians is enhanced above and beyond any difference in general cognitive ability (Jakobson, 2008; Ho et al., 2003; Franklin et al., 2008). It is also important to consider the possibility that enhanced verbal memory in musicians is due to the presence of certain personality traits, or pre-existing differences in brain structure, or certain backgrounds that favour verbal memory ability. There is, however, substantial evidence to support a causal relationship between enhanced verbal memory and years of music training.

For example, Jakobson, Cuddy and Kilgour (2003) found that the duration of music training dictated the degree of improvement of verbal memory. This provides evidence of causation, as verbal memory improves more or less according to the amount of music training.

To conclude, the present study supports the findings of previous studies in showing an enhancement in verbal memory as a result of music training. This was a general effect in that it was observed with three lists featuring words high in imagery (visual, auditory, or tactile) and also with a list of abstract words. A useful aim for future research would be to further establish a causal link between enhanced verbal memory and music training. Longitudinal studies which commence before music training and test at various intervals throughout music training would provide strong evidence of any neurological or cognitive changes resulting from music training (see Norton, Winner, Cronin, Overy, Lee, & Schlaug, 2005, for preliminary findings from such a study). Longitudinal studies would provide a clearer picture of how verbal memory develops with music training. In the meantime, the current study adds to the growing body of evidence that music training leads to enhancements in cognitive processes that are not specific to the domain of music.

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Appendix 1: Words lists

Auditory:

Crash, hiss, growl, scream, roar, echo, clap, gurgle, hum, slam, murmur, shout, mutter, whisper, rustle, silence, sigh, sing, talk, voice.

Visual:

Bike, boat, scarf, key, tree, ruler, pen, desk, trousers, candle, pillar, guitar, scissors, chair, computer, bag, bottle, sofa, clock, bin.

Tactile:

Fluffy, brittle, rough, sharp, smooth, cold, dry, slippery, squashy, furry, firm, leathery, grainy, silky, bumpy, spongy, waxy, prickly, woolly, soft.

Abstract:

Wisdom, explore, trust, liberty, sympathy, reality, laziness, apt, humility, victory, success, alias, brave, luck, vague, riches, mercy, humour, honesty, gist.

Table 1. Mean correct recall (with standard deviations) as a function of group and list type

List Type	*Musicians*	*Non-musicians*
Visual	8.00 (3.77)	7.25 (2.75)
Auditory	8.95 (3.07)	7.55 (2.19)
Tactile	8.75 (2.12)	7.80 (2.86)
Abstract	7.25 (2.22)	5.00 (2.10)
Total	32.95 (11.18)	27.60 (9.9)