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S.A. Deffler

Andrea Halpern
Bucknell University, ahalpern@bucknell.edu

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BRIEF REPORT

Contextual Information and Memory for Unfamiliar Tunes in Older and Younger Adults

Samantha A. Deffler and Andrea R. Halpern
Bucknell University

We examined age differences in the effectiveness of multiple repetitions and providing associative facts on tune memory. For both tune and fact recognition, three presentations were beneficial. Age was irrelevant in fact recognition, but older adults were less successful than younger in tune recognition. The associative fact did not affect young adults' performance. Among older people, the neutral association harmed performance; the emotional fact mitigated performance back to baseline. Young adults seemed to rely solely on procedural memory, or repetition, to learn tunes. Older adults benefitted by using emotional associative information to counteract memory burdens imposed by neutral associative information.

Keywords: aging and music memory, associative memory, emotion and memory

People can remember familiar music for long periods of time without much rehearsal (Bartlett & Snelus, 1980). However, compared with younger participants, healthy elderly listeners have lower performance on old/new recognition tasks of both familiar and unfamiliar tunes (Bartlett, Halpern, & Dowling, 1995), which cannot be overcome by musical expertise (Halpern, Bartlett, & Dowling, 1995). Music's importance to the daily life of seniors (Cohen, Bailey, & Nilsson, 2002) makes research into the nature of musical learning and memory valuable, especially as we consider whether memory for music follows the same pathway of decline as memory in other modalities. To investigate musical memory in older adults, we examined age differences in the effects of repetition and provision of additional contextual information in the learning of new tunes.

Repetition of a tune may enable older adults to overcome their memory deficit. Multiple repetitions of an item enhance memory in younger adults (Cary & Reder, 2003), particularly if spaced (Kornell & Bjork, 2008). Furthermore, Kornell, Castel, Eich, and Bjork (2010) confirmed that multiple spaced repetitions also improve memory performance in older adults. Repetition plays a part in learning of music, clearly seen in the importance of practice as musicians master their craft. Here we investigated the effect of a single presentation versus three spaced presentations.

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Samantha A. Deffler and Andrea R. Halpern, Department of Psychology and Neuroscience, Bucknell University.

Samantha A. Deffler is now at Duke University.

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Correspondence concerning this article should be addressed to Samantha A. Deffler, Department of Psychology and Neuroscience, Duke University, Durham, NC 27708. E-mail: samantha.deffler@duke.edu

Simple repetition may not enable sufficient memory encoding of the tunes and may require mediation of additional information. To remember an event, people must not only encode its different features, but also bind those features together to create a coherent memory. Naveh-Benjamin, Brav, and Levy (2007) showed that associating two words at encoding was more beneficial than using no association; the benefit of an association was greatest when the strategy was used at both encoding and retrieval. It is most interesting to note that older adults showed greater improvement than younger adults from the no-strategy condition to the association condition. This finding suggests an association may help to lessen the memory deficit attributable to aging. To test whether the benefit of associations translates into the musical domain, the current study presented short associative facts along with some tune-category pairs during encoding.

However, the mere presence of an associative fact may still not be enough to overcome the age-related deficit in encoding of new information. In a study by Castel and Craik (2003), older adults and younger adults studied unrelated word pairs and were then given a recognition task and an associative task. Paradoxically, older adults had a greater deficit on the associative task, possibly because the associative fact may only add to the memory load of the older adults. Chalfonte and Johnson (1996) and Kessels, Hobbel, and Postma (2007) showed that older adults perform as well as younger adults on tests of memory for features, such as color and object type. However, an age-related deficit occurred on tests where the features had to be bound together, suggesting that the age-related memory deficit may be mediated by binding difficulties. It is unclear whether binding of intrinsically meaningful information would be more harmful or helpful to older adults.

Our tunes were presented with a randomly assigned category name. We hoped that the category label would allow some scaffolding of the purely auditory information onto familiar knowledge. However, to examine older adults' possible difficulty with feature binding, we also included an additional associative (fictional) fact in some conditions to investigate how well contextual information could be bound with a tune to assist encoding and retrieval.

Binding problems might be mitigated by the type of feature. In this study, the associated fact was either neutral or emotional. People remember details of emotional stories, pictures, words, and music more accurately than neutral stimuli (Burke, Heuer, & Reisburg, 1992; Kensinger & Corkin, 2003; Nieuwenhuis-Mark, Schalk, & de Graaf, 2009; Eschrich, Münte, and Altenmüller, 2008). Emotional stimuli may increase memory through the activation of the amygdala, which influences memory encoding, consolidation, and retrieval via connections with the medial temporal lobes (MTL) (Dolcos & Denkova, 2008). Furthermore, the effect of emotion on memory appears to be preserved in older adults (Denburg, Buchanan, Tranel, & Adolphs, 2003; May, Rahhal, Berry, & Leighton, 2005). Older adults appear to have preserved amygdalar function and, in the face of decreased MTL function, also show increased dorsolateral prefrontal cortex activation, a possibly compensatory process (St Jacques, Dolcos, & Cabeza, 2008). Thus, older adults might benefit from the presentation of emotional information in a tune memory task even if they do not benefit from (or are even harmed by) neutral information.

To summarize, we presented unfamiliar melodies for later incidental testing. We varied the type of association and number of repetitions. We hypothesized that younger adults would be more accurate than older participants and three presentations would always be more beneficial than one presentation, with a possible extra benefit for the older adults who would likely have lower initial performance levels. We also predicted that younger adults would benefit from either type of extra fact because of their ability to bind meaningful information at encoding; however, because of their age-related reduction in memory capacity (Craik, 2000), older adults would not benefit from the neutral fact condition but would benefit from the emotional fact.

Method

Participants

Twenty-eight undergraduates with a mean age of 18.93 (0.90) years and 27 older participants with a mean age of 69.68 (7.68) years, recruited from a local Lifelong Learning Institute, were tested. Data from two older participants could not be analyzed; one failed to follow directions on the tune recognition test and the other had a vocabulary score on the second half of the Weschler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981) that was significantly lower than all other participants. Students were given class credit for participation; senior adults were given a movie ticket. Overall, older adults had significantly more years of education (M = 17.08 SE = 2.72) than younger adults (M = 12.61 SE = .83). Older adults also had higher WAIS-R vocabulary scores (M = 31.06, SE = 4.68) than younger adults (M = 23.86, SE = 7.04).[1] When taking into account an inequality of variances, as indicated by a Levene's test (F = 10.76, p = .002), younger (M = 5.18, SD = 3.12) and older adults (M = 13.80, SD = 21.31) did not differ on years of musical education.

Materials

Ninety-six unfamiliar tunes without lyrics were selected from a large collection of tunes composed by trained musicians for previous experiments. The mean duration of the tunes was 6.71s (SD = 1.58). All melodies sounded like plausible tunes and were played in a piano timbre at a comfortable volume on high-quality speakers. To reduce the possibility of any intrinsic relationships between tunes and putative categories, the tunes were divided into two sets and assigned to three semantic categories at random.

Six different presentation lists for each tune set were created so that each tune served nearly equally often in one and three presentation conditions, and in category, category and neutral fact (cat + NF), and category and emotional fact (cat + EF) conditions. First, one-sentence facts were composed in triplets, pertaining to categories of religious, patriotic, and nature. The triplets were matched in length and general context but contained one each of a neutral, positive, and negative fact. For example, one composed triplet was: A soldier played this tune during 1) military exercises, 2) . . . an awards ceremony, 3) . . . a military funeral. The facts were then rated for affect on a scale from −5 (very negative) to + 5 (very positive) by five students. Neutral facts rated on average from 0.00 to + 1.00 and emotional facts rated either from −4.33 to −3.33 or + 4.33 to + 3.33 were used. Because the emotionality ratings for facts varied, an equal number of facts from each category could not be used. Six patriotic, six religious, and four nature facts were used in each set; half the emotional facts were negative and half positive. Including the category only condition, this resulted in 12 nature, 18 patriotic, and 18 religious songs in each set.[2]

Procedure

In the initial presentation phase, participants were informed that a category would be presented before a tune was played; they were also told that another fact about the melody might be presented. Participants were instructed to remember the association between the tune and the category for a later categorization task and also to attend to the facts for a later fact recognition task; they were not informed of the future tune recognition task to capture how people normally learn music in everyday situations. In particular, we wanted to make sure that people were paying attention to the facts, hence the intentional instructions. The intentional instructions also allowed this task to serve as a baseline to make sure our older participants had no unusual memory impairments.

During the presentation phase, three types of textual displays were presented on the computer screen along with the tune: category name, cat + NF, or cat + EF. The information in the category condition was displayed for 2 s before the tune started to play; the other two conditions were displayed for 3 s. Once the tune was finished, the screen went blank for 0.7s before the next trial. This section took approximately 9 min. A total of 48 tunes were

[1] To examine effects of vocabulary on memory for music, we also analyzed our data using analysis of covariance (ANCOVA), with WAIS-R vocabulary score as a covariate. None of our critical interactions changed using this analysis.

[2] Because of this methodology, we did not have enough data to separate positive associative fact trials from negative associative fact trials.

presented. Half of these melodies were presented three times; at least two tunes occurred between repetitions. Half of the participants heard tunes from one set in the presentation phase and half heard tunes from the other set.

After the presentation phase, volunteers defined the final 20 words from the WAIS-R vocabulary test, which took approximately 10 min, followed immediately by the old-new tune recognition test. Of the 48 melodies tested, half had been heard by the participants during the presentation phase. The new tunes were taken from the stimulus set not utilized for the category-learning phase. Participants then categorized the 48 tunes from the presentation phase as religious, patriotic, or nature.

After the categorization task, participants completed a fact recognition task comprising all of the 32 facts used in the presentation phase plus 16 new neutral and emotional facts, taken from the initially composed facts. Each new fact was from an old fact's triplet, so it resembled the old fact in length and general content. Finally, participants were debriefed.

Results

Originally, we had planned to examine how well people remembered the semantic category of the tunes, but this task proved to be surprisingly difficult and thus we omit formal analyses because of near-chance performance in some conditions.

Fact Recognition Task

Data from the fact recognition task helped verify how well the facts had been learned. Overall, participants performed well on this task. Collapsed across groups, hit rates were high ($M = .89$, $SE = .01$) and false alarm rates were low ($M = .11$, $SE = .01$). Two *t*-tests were performed to examine age differences on hit rate and false alarm rate. To correct for this build-up of family-wise error rate and control for Type I errors, the significance level was designated as $.05/2 = .025$. An effect of age, $t(51) = 2.66$, $p = .010$, $d = .73$, was only found on the hit rate; younger adults had more hits than older adults (Table 1).

We combined hit and false alarm rates into *d'* scores as a standard measure of discrimination. A $2 \times 2 \times 2$ repeated measures analysis of variance (ANOVA) was performed with group (young, old) as a between-subjects factor and number of presentations (one, three) and association type (neutral fact, emotional fact) as within-subjects factors. Younger and older participants performed similarly, $F(1, 51) = 2.78$, $p = .10$, but not at ceiling levels. Participants remembered emotional facts ($M = 2.73$, $SE = .10$) better than neutral ones ($M = 2.56$, $SE = .12$), $F(1, 51) = 5.63$, $p < .001$, $\eta_p^2 = 0.10$. Also, three presentations of a fact ($M = 3.25$, $SE = .11$) benefited recognition more than one presentation ($M = 2.04$, $SE = .11$), $F(1, 51) = 405.15$, $p < 001$, $\eta_p^2 = 0.89$. We found no interactions, including any with age.

Table 1
Overall Task Performance

Task	Younger	Older
Fact recognition		
Hit rate	.85 (.01)	.79 (.02)*
False alarm rate	.11 (.02)	.12 (.02)
d'	2.59 (.15)	2.20 (.14)
Tune recognition		
Hit rate	.78 (.02)	.71 (.02)*
False alarm rate	.29 (.03)	.43 (.03)**
d'	1.44 (.11)	.76 (.10)**
C	−.10 (.06)	−.20 (.06)

Note. *SE*s of the mean are in parentheses. These means represent group performance collapsed across levels of the within-subjects factors.
* Significant age difference, $p < .025$. ** Significant age difference, $p < .01$.

Tune Recognition Task

Data from the tune recognition task allowed us to determine if the number of presentations and association type manipulations aided in incidental memory for the tunes. Hit rates collapsed across group were relatively high ($M = .75$, $SE = .01$), but people committed more false alarms ($M = .36$, $SE = .02$) than in the fact recognition task. Two *t*-tests were performed to examine age differences on total hit rate and false alarm rate using a significance level of $.05/2 = .025$. Compared to the older adults, the younger adults had a higher hit rate, $t(51) = 2.60$, $p = .012$, $d = .71$, and a lower false alarm rate, $t(51) = 3.54$, $p = .001$, $d = .97$, in a pattern often referred to as a mirror effect (Glanzer & Adams, 1985).

Figure 1 shows the *d'* scores across variables. We carried out a $2 \times 2 \times 3$ repeated measures ANOVA with group as a between-subjects factor and number of presentations and association type as within-subjects factors. Younger adults ($M = 1.82$, $SE = .12$) scored higher overall than older adults ($M = .99$, $SE = .13$), $F(1, 51) = 21.94$, $p < .001$, $\eta_p^2 = .30$. Also, three presentations ($M = 1.94$, $SE = .10$) elicited higher *d'* scores than one presentation ($d' = .87$, $SE = .10$), $F(1, 51) = 108.23$, $p < .001$, $\eta_p^2 = .68$. The association type manipulation did not affect performance, $F(2, 102) = .16$, $p = .850$.

An interaction was found between number of presentations and group, $F(1, 54) = 14.38$, $p < .001$, $\eta_p^2 = .22$, and between association type and group, $F(2, 106) = 8.62$, $p < .001$, $\eta_p^2 = .15$. Bonferroni-corrected paired *t*-tests showed that whereas both younger and older adults performed better with three presentations, the younger adults benefited more ($p < .001$). Contrary to our hypotheses, we found no effect of association for the young adults. However, for the older adults, the neutral fact hurt performance relative to the baseline of no fact ($p = .009$), with a recovery of performance to baseline if the fact was emotional ($p = .048$).

An analysis on *C* scores showed that younger and older adults had similar overall bias, $F(1, 51) = .06$, $p = .803$.

Discussion

To summarize our major findings: we found a benefit of three presentations for all tasks. There were no age differences in fact recognition. Among older people, the memory burden of a neutral association was lessened when the association was emotional for tune recognition.

The fact recognition task allowed us to analyze whether participants were attending to and encoding the associative facts along with the tunes. The high *d'* scores indicate that participants were encoding the associative facts, and indeed, older and younger people remembered them equally well. The benefit of emotion on

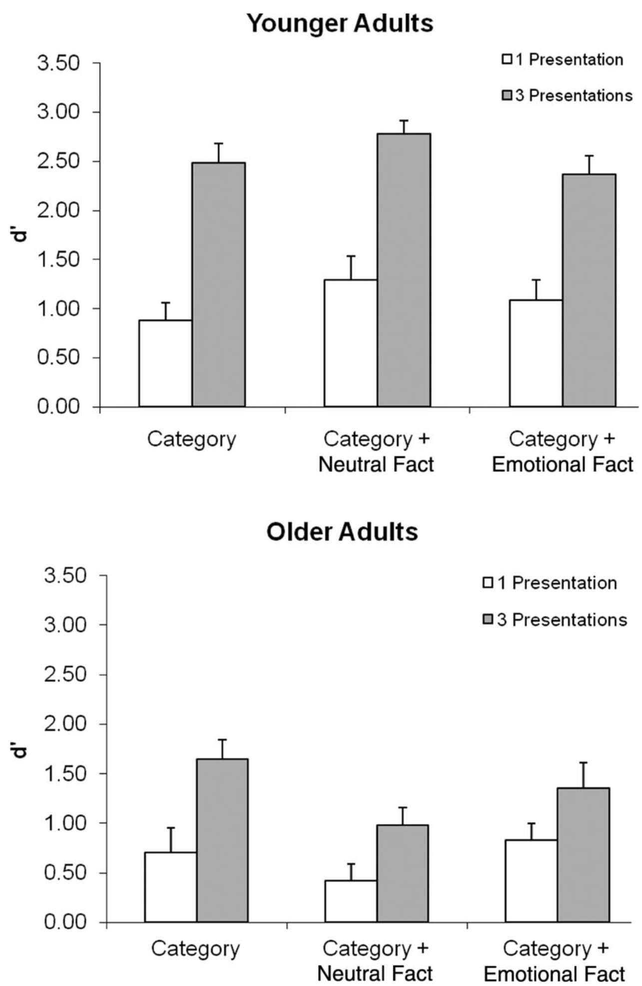

Figure 1. Discrimination scores (*d'*) on tune recognition in younger and older adults. Error bars represent *SEM*s.

fact recognition also serves as verification that the two types of facts differed in their effect as we intended them to.

In incidental tune recognition, the overall age effect replicates the findings of other studies regarding age effects on music recognition (Bartlett et al., 1995; Halpern et al., 1995). The current data support the idea that musical memory, much like other forms of memory, is age sensitive (Monti et al., 1996; Lazzara, Yonelinas, & Ober, 2002; Park, Smith, Morrell, Puglisi, & Dudley, 1996). The similarity between age effects in memory for music and in other modalities suggests that strategies devised to maintain older adults' memories may be applicable to music. The absence of an age effect in bias scores shows that the age effect was the result of true memory differences, and not any possible increased or decreased willingness to say "old" among older people.

Contrary to our hypotheses, young adults showed no effect of association type. However, association type did affect older participants' performance. As we predicted, a neutral fact did not help the older adults to remember tune information, and in fact hurt memory. The older adults may not bind the neutral association to the novel tune in memory, instead treating the fact and tune as separate events. The associative fact may overwhelm their already compromised working memory (Park et al., 1996; Craik, 2000), leading to the decline from baseline. The encoding of an emotional fact also likely strains older adults' working memory. However, the relative age-sparing of emotional memory may serve to counteract this decline, resulting in performance no different than baseline.

One possible methodological refinement to the study would be to examine whether there is a difference between memory for tunes designated by positive versus negative associations. Older adults may show a positivity bias, or increased accessibility to positive information. Research by Spaniol, Voss, and Grady (2008) supports this hypothesis, as indicated by an overall greater familiarity for positive items in older versus young adults. However, this bias may be caused by suppression of negative information as a form of emotional regulation that adversely affects memory for negative stimuli (Cartensen, Isaacowitz, & Charles, 1999; Grühn, Scheibe, & Baltes, 2007). Furthermore, Allen, Kaut, Lord, Hall, and Grabbe (2005) postulate that the changes in positive and/or negative memory found in older adults are mediated by individual differences, such as neuroticism and extroversion, that need to be taken into account when examining age effects on memory. It may be these intrapersonal differences that are causing the effects, instead of a universal "rule" of normal aging.

As a final observation, we note that encoding of tunes may not always benefit from associations or emotionality as other forms of memory do. The robust effect of multiple presentations suggests that repetitions of a melody may be the only truly helpful strategy for musical memory, and is more effective in younger people. However, older adults derive many benefits from participating in musical activities. They retain, and in some cases increase, a variety of musical listening skills through passive exposure to or rehearsal of music over a lifetime (for a review, see Halpern & Bartlett, 2002). As the older people here did increase their learning with three repetitions, we can suggest that music teachers interacting with younger or older adults may wish to build repetition of musical examples into their courses.

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