

2010

Semantic Categorization of Unfamiliar Tunes in Older and Younger Adults

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**SEMANTIC CATEGORIZATION OF UNFAMILIAR TUNES
IN OLDER AND YOUNGER ADULTS**

by

Samantha A. Deffler

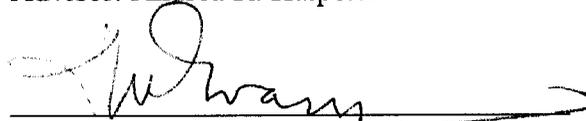
A Thesis Submitted to the Honors Council
For Honors in Neuroscience

May 4, 2010

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Acknowledgments

I extend thanks to the Bucknell Institute for Lifelong Learning, especially Ruth Burnham and Edward Cotter, for help recruiting older research participants. Also, special thanks to Professor Andrea Halpern. I could not have completed this project without your guidance.

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Abstract

The process of learning the categories of new tunes in older and younger adults was examined for this study. Tunes were presented either one or three times along with a category name to see if multiple repetitions aid in category memory. Additionally, to examine if an association may help some listeners, especially older ones, to better remember category information, some tunes were presented with a short associative fact; this fact was either neutral or emotional. Participants were tested on song recognition, fact recognition, and category memory. For all tasks, there was a benefit of three presentations. There were no age differences in fact recognition. For both song recognition and categorization, the memory burden of a neutral association was lessened when the association was emotional.

Introduction

People remember music for long periods of time without much rehearsal. They may remember these tunes by cognitively organizing them, but we do not know how. A study by Bartlett and Snelus (1980) examined middle-aged and senior adults' long-term memory for songs heard between 1921 and 1974. Although listeners had not heard many of the tunes since their time of popularity, as long as 50 years prior to the study, they were still able to accurately recall lyrics when cued with a song title or melody. These results attest to the enduring nature of musical memory, particularly for popular songs. However, given the surprising persistence of these musical memories, how are people able to correctly recall songs that they have not heard in several decades?

We know that to accurately remember anything, the mind must organize the information in a coherent and retrievable manner. Halpern (1984) suggests that one stores tune memories in cognitively organized, semantically-related clusters. In one experiment, Halpern asked participants to group familiar tunes according to their musical similarity or by some other criterion. Using a tree-fitting program to organize the data, she found that the participants were not able to group songs coherently according to musical similarity. However, when asked to group according to a non-musical criterion, participants clearly grouped songs according to the song's real-life category, such as "patriotic" and "folk." Although no research has been done on how these tunes become organized in memory, this conceptually driven clustering of songs suggests that people categorize memories for familiar tunes according to experience, and group songs through associations with these categories.

Long-term Musical Memory

Despite the absence of research into the nature of tune categorization, a significant body of research examines long-term musical memory for both well-known and novel tunes. Generally, recognition for well-known tunes is more accurate than for novel tunes. A study by Bartlett, Halpern, and Dowling (1995) supports this assertion. In one experiment from the study, normal young adults and normal elderly adults were presented with separate sets of well-known and novel tunes, and then given an old/new recognition task. Although the elderly adults exhibited a lower performance than their younger counterparts, both groups exhibited a mirror effect of increased hits and decreased false alarms for the well-known versus the novel tunes. It appears that people, regardless of age, have an easier time recognizing well-known tunes that they have previously heard and they are less likely to falsely say that a new well-known tune is old. Other studies of musical memory also support the greater accuracy of recognition for well-known tunes (Demorest, Morrison, Beken, & Jungbluth, 2008; Dowling, Bartlett, Halpern, & Andrews, 2008). Memory for well-known tunes may be better than memory for novel tunes because the tunes have already been encoded in memory. Memory for novel tunes may be strengthened if a participant can encode the novel tunes in a way that he or she represents well-known tunes, such as by category.

Aging and Memory

The effect of aging revealed by Barlett et. al. (1995) is also not a surprising result. In fact, cognitive aging has been shown to affect long-term memory across many domains. Monti et. al. (1996) studied younger and older adults' performances on cued-

recall of studied words and a category-exemplar generation task to measure explicit memory and used priming effects to capture implicit memory. The ability to recall information is a form of explicit, or conscious and intentional, memory; priming effects show the presence of implicit, or unconscious and unintentional memory. They found that younger adults performed better than older adults on the cued-recall task, but there was no effect of age on the priming task.

Recall requires more effortful processing because a person must generate his or her own retrieval cues, a process that may be affected by aging (Craik & McDown, 1987). It may therefore be suggested that the difference between older and younger adults found by Monti et. al. (1996) represents a decline in performance specifically on a recall task. However, Lazzara, Yonelinas, and Ober (2002) looked at picture and word memory and revealed an effect of aging on recognition memory, indicating that explicit memory as a whole is affected by aging. Importantly, elderly participants showed priming effects similar to younger participants. These findings, coupled with the work of Monti et al. (1996), provide support for the idea that aging leads to a decline in a person's ability to accurately remember explicit information, but leaves their implicit memory intact. Because aging effects on explicit memory can be measured regardless of test, it is possible to test the effect of aging on musical memory, which is typically measured by recognition.

The explicit memory deficit of older individuals has been linked to decline in two separate cognitive abilities that were documented by Park et al. (1996). Over 300 participants ranging in age from 20 to 90 were given an extensive cognitive exam. Both

working memory abilities and speed of cognitive processing played a role in the lower performance of elderly individuals. Interestingly, these two constructs did not always affect the same tests of explicit memory. It appears that working memory and the speed of cognitive processing independently decline with age. Although these processes make different contributions to different aspects of explicit memory, the combined deficits from both systems create an overall decline in explicit memory due to aging.

Working memory may play an important role in performance on the tasks in this experiment. Working memory is memory for information that is being processed or actively manipulated. It declines throughout adulthood, possibly due to a decline in mental “energy” or processing capacity. When older adults must retain a lot of information in memory, their decreased processing capacity may lead to the loss of more information than younger adults would lose (Craik, 2000). Therefore, tasks that require the retention or integration of large amounts of information are more affected by aging deficits than those with fewer, or less complex, things to remember.

Aging and Musical Memory

The aging deficit in musical memory is similar to those found in other domains. As discussed previously, Bartlett et al. (1995) discovered that healthy elderly listeners had a lower performance on old/ new recognition tasks of both familiar and unfamiliar tunes when compared with their younger counterparts. This result provides proof that the aging deficit extends to musical memory. Halpern, Bartlett, and Dowling (1995) further supported this assertion in one part of a transposition recognition study using musical experts and novices. They found that regardless of musical expertise, there was still an

age difference on old/new recognition task results. In fact, although experts exceeded novices on false alarm suppression, there was no reliable effect of experience on test performance once vocabulary was used as a covariate. It appears that, at least in the case of old/new recognition of melodies, musical experience is not enough to overcome the effects of cognitive aging on musical memory.

However, in a review of studies of aging and musical memory, Halpern and Bartlett (2002) provide evidence of a more complex relationship between aging and musical cognition. They found several studies showing that aging effects were more profound than experience effects on tests of musical memory, but only on those that did not require domain-specific knowledge. On tests of memory that required musical knowledge, such as that of tonal structure, the effect of musical experience was greater than the effect due to aging. Importantly, this decreased age effect for these domain-specific tasks was especially pronounced at slower task speeds, indicating that the cognitive slowing associated with aging most likely also applies to musical tasks. This review provides a clearer understanding of the effect of aging on musical memory, particularly that aging affects those tasks that do not require domain-specific knowledge, such as old/new recognition tasks.

Aging and Category Memory

The previously discussed studies appear to paint a bleak picture of an aging memory. However, it is important to note that these findings all pertained to the effect of aging on memory for individual items. Category memory, or knowledge of the category of an individual item, appears to be affected by aging to a lesser degree. The strategies

that people utilize to categorize items into coherent groups change over time. Denney's (1974) study of categorization strategies in older and younger adults revealed differences between the two age groups. When asked to group objects that varied in shape, size, and color into similar groups, older adults indicated more "no similarity" objects and were also more likely to place the objects into a design instead of discrete groups based on similarity. However, when shown the correct way to categorize through an instructor's modeling according to similarity, older adults were able to categorize new shapes according to the model. Elderly adults appear to still retain the ability to group according to similarity, but they tended to prefer to group the objects based on design; this method of categorization is preferred by young children and is therefore considered not as complex as grouping by similarity.

A difference due to aging also occurs when older adults are asked to place familiar objects into groups based upon similarity. Cicirelli (1976) studied categorization behavior in five to seven years old children, young adults, and elderly adults by having participants group line drawings of familiar objects "that seem to belong together." He found that older adults, like young children, were more likely to group objects according to a relational-thematic criterion, where there is a functional relationship between the objects. An example of relational-thematic grouping would be placing a hammer and a nail in the same group. Also, older adults had fewer groups and more ungrouped items, indicating an inability to find relationships between items. Younger adults, on the other hand, grouped objects according to observable traits or membership in a superordinate group. This observed change in categorization behavior is linked to a loss due to aging,

because older adults' categorization is devolving to resemble the behavior of young children.

The previously described categorization studies dealt with free-sorting tasks where participants determined the rules of categorization. In another type of task, called a feedback learning task, participants learn to categorize according to a predetermined method from positive and negative feedback. Filoteo and Maddox (2004) utilized this task to study two different types of category learning. Rule-based learning involves categorization criteria that can be learned explicitly; the rule can often be explicitly stated. Information-interaction learning, on the other hand, involves the implicit integration of two or more stimulus components; this method is often impossible for the participant to verbally describe. During a feedback learning task involving the categorization of lines varying in orientation, older adults were less accurate than younger adults in this information-interaction learning situation. Older adults also were more likely to use a rule-based method of categorization, despite negative feedback from the instructor. Quantitative modeling revealed that older adults have a greater difficulty utilizing information-integration category learning than rule-based learning, suggesting that despite the deficits due to aging seen in rule-based category learning, older adults are more likely to utilize this less-complex form of categorization in lieu of an information-integration strategy.

The impact of age on categorization does not just apply to placing items into categories; it also extends to the naming of category exemplars from memory. Moreno-Martinez, Laws, and Schulz (2008) presented healthy young adults, healthy older adults,

and Alzheimer's Disease patients with categories of living and nonliving things and asked them to recall members of the categories. There was a significant effect of aging, with healthy elderly adults naming far fewer category exemplars than their younger counterparts. These results indicate that older adults may also suffer from a decline in their ability to recall category members, in addition to the differences due to aging in the placing of items into categories.

Although much is known about the effect of aging on musical item memory, a recent database search revealed that no work has been done on the relationship between aging and musical categorical memory. Zentall, Galizio, and Critchfield (2002) propose the existence of *associative* categories that relate items not by their inherent qualities but rather by their function, such as how Christmas and Labor Day are holidays, even though they share no specific qualities. Because humans categorize music based upon nonmusical qualities, like what event or time period a song is associated with (Halpern, 1984), musical categorization is likely based upon associative concepts. However, how does a song become associated with a particular category?

Categories Learned via Repetition

Repetition of a song in connection with a category may be enough to encode category information. One principle of memory is that multiple repetitions of an item enhance memory. Cary and Reder (2002) discovered that the greater the number of presentations of a common noun, the better a participant recognizes the word. Musicians' learning of music through practice shows that these findings also apply to music. Moreover, spacing of learning trials makes practice most effective. Kornell and Bjork

(2008) examined the effect of presentation order of exemplars on participants' ability to correctly categorize new works of art. They found that whereas viewers believed that massed presentation (multiple consecutive presentations) improved their category learning, it was actually spaced presentation (multiple nonconsecutive presentations) that increased the accuracy of participants' categorization.

To test if the effect of multiple spaced presentations translates into the musical domain, one level of the experimental design here examined the effect of a single presentation versus three spaced presentations. We expected that multiple presentations of a song will increase the accuracy of a listener's musical memory. However, the extent of this effect should vary depending upon a person's age, since the accuracy of explicit item memory across domains generally decreases as a person ages. We predicted that three presentations would increase older adults' performance versus one presentation more than it does for the younger adults. The older adults would need these additional presentations because of their explicit memory decline; younger adults would experience sufficient encoding during the first presentation.

Categories Learned via Factual Associations

Although multiple presentations of a stimulus lead to better item recognition, this effect has not been studied for semantic, or categorical, knowledge. Repetitions of a song and its category name may not be sufficient to encode the relationship in memory. Because musical categories appear to be associative categories, the presence of associative information during tune and category presentation may be necessary for strong encoding. The effect of associations on memory was studied by Naveh-Benjamin,

Brav, and Levy (2007). They asked younger and older adults to learn word pairs using an intentional-learning strategy (participants simply read the word pairs), an associative strategy at encoding (participants related the two words in a sentence at encoding), or an associative strategy at encoding and retrieval (participants related the two words in a sentence at encoding and tried to recall the relationship at retrieval). As expected, younger adults performed better overall than older adults at the task. Also, an effect of strategy was found, with any associative strategy being more beneficial than the intentional-learning strategy, and the associative strategy being most beneficial when used at both encoding and retrieval. Most interesting, there was an interaction between aging and strategy: Older adults showed a greater improvement in performance when using any associative strategy than did the younger adults. This finding suggests that the presence of an association may help to lessen the memory aging deficit. To test if the benefit of associations translates into the musical domain, a short associative fact was presented along with some song-category pairs during encoding.

It is possible that the presence of an associative fact will not be enough to overcome the aging deficit. 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. Older adults had a greater deficit on the associative task, possibly because it is harder for older adults to form associations between unrelated pairs. This contradictory finding questions whether the presence of an associative fact will be enough to overcome the older adults' memory deficit. Instead, the associative fact may

only add to the memory load of the older adults, making it more difficult for them to accurately remember category information.

Categories Learned via Emotional Associations

Because emotional material is less affected by aging, having participants read an emotional fact as opposed to a neutral one may facilitate even better encoding of categorization, especially for elderly adults. Burke, Heuer, and Reisberg (1992) found that when participants viewed slides that were accompanied with an emotional narration, they remembered details of the story and slide better than when the accompanying narration was neutral. As detailed by Hamann (2001), emotional stimuli activate the amygdala, which influences memory encoding and consolidation in ways not seen with neutral stimuli. Hamann believes that the vividness of emotional memories is an evolutionary construct designed to aid in human survival. The mechanisms that enhance emotional memories are not engaged for neutral memories.

The benefits of emotionality are not just conveyed on everyday visual scenes or experiences. Kensinger and Corkin (2003) asked participants to remember negative and neutral words, and found that volunteers' memories for the negative words were more accurate and detailed. The addition of a remember/know component showed that participants "remembered" negative words more often than neutral words, indicating that the negative word memories were stronger. Nieuwenhuis-Mark, Schalk, and de Graaf (2009) utilized a similar word task with healthy, mildly impaired, and Alzheimer's-affected elderly adults. All three groups recalled emotional words better than neutral words; there was no advantage for positive versus negative words. These results suggest

that emotional memory may be preserved in the elderly. However, because only older adults were included in the study, one is unable to conclude what effect aging has on emotional memory.

Other findings, however, do allow for the conclusion that emotional memories are preserved in the elderly. Denburg, Buchanan, Tranel, and Adolphs (2003) tested older, middle-aged, and younger adults on their memories for pictures with emotional and neutral narratives; no effect of aging was found for emotional memories. There was, however, an effect of aging on memory for neutral narratives. These results are supported by those of May, Rahhal, Berry, and Leighton (2005), who examined younger and older adults' memories for perceptual, nonemotional conceptual, and emotional conceptual information. Not surprisingly, younger adults outperformed older adults on tests of perceptual and nonemotional conceptual information. However, younger and older adults performed equivalently on the test for emotional conceptual information. These findings support the notion that the encoding of emotional stimuli remains stable throughout the life span.

To test whether emotion affects how people put songs into groups, we presented some tune-category pairs with an emotional associative fact. We expected this association to benefit both participant groups, but with a particular benefit to the older adults because of their preserved emotional memory. The idea that benefits of emotional memory may also be present in the musical domain is supported by a study by Eschrich, Münte, and Altenmüller (2008). They found that when listeners rated positively rated unfamiliar

tunes as emotionally positive, they were remembered better than those that were rated emotionally neutral.

Hypotheses

To summarize our hypotheses, we expected that both item and category memory would be influenced by aging, number of presentations, and type of association. Because of the associative nature of memory, we predicted that the presence of any association would lead to better encoding than no association. Also, we hypothesized that given the aging effects found in memory, younger participants would be more accurate than older participants. Also, we expected three presentations to always be more beneficial than one presentation because previous findings on the helpfulness of multiple presentations.

We also expected a three-way interaction among the variables. The type of cue should interact with number of presentations, but this interaction should differ depending upon participant age. For the younger participants, three presentations would be most beneficial when no associative fact is present. This benefit would decrease for neutral facts; three presentations would be least beneficial for an emotional fact. In older listeners, we predicted that three presentations would be equally beneficial for no association and neutral association conditions, because the presence of a neutral fact was just adding to participants' memory load. However, the effectiveness of three presentations versus one presentation would decrease for elderly participants when an emotional association was present because of the robustness of older adults' emotional memory.

Experiment 1

For Experiment 1, participants studied tune-category pairs, two-thirds of which had an accompanying neutral or emotional associative fact. During testing, participants first completed a surprise song old/new recognition task to allow for the analysis of the effect of age, multiple presentations, and association type on the item memory for the tunes being presented. Afterwards, participants completed a categorization task for the tunes to assess the effect of age, multiple presentations, and association type on category memory. We conducted this experiment on young adult participants in anticipation of testing older participants as well. However, upon initial statistical analysis it became apparent that our methods needed to be revised before we tested older adults. Experiment 2 resulted from these revisions.

Methods

Participants.

We recruited 32 young adults from the Psychology 100 Subject Pool for this experiment. Two participants were removed from the sample, leaving a total of 30 participants for statistical analysis. One participant skipped a song on the song old/new recognition task; the other was using a cell phone and ignoring the information on the computer screen during the study phase of the experiment. The students were given class credit for their participation. Before the start of the experiment, all participants completed a musical background questionnaire. Results of the questionnaire and other participant demographics can be found in Table 1.

Materials.

Ninety-six unfamiliar tunes composed by trained musicians were used for this experiment; the tunes did not have lyrics. The mean duration of the tunes was 6.71s (SD = 1.58). All melodies sounded like plausible songs and were played in a piano timbre at a consistent volume. The 96 tunes were divided into an A set and a B set randomly.

The number of presentations and the type of association for each tune varied within six different subject sets. For example, a tune that was repeated three times with a neutral fact for one participant group would be played only once with just a category name for another participant group. Tune facts were constructed so that they applied to one of the three categories: Religious, Patriotic, and Nature. First, a large number of one-sentence facts were composed in triplets. The triplets were matched in length and general context but contained one each of a neutral, positive, and negative. For example, one composed triplet was: 1) On All Saints Day, this melody played throughout the Baker House. 2) On All Saints Day, this melody played as the Bakers were surprised with presents. 3) On All Saints Day, this melody played as Mr. Baker drove to the emergency room. The composed facts were then rated for neutrality or emotionality on a scale from -5 (very negative) to +5 (very positive) by five volunteers. Only neutral facts rated on average from 0.00 to +1.00 were used. Emotional facts selected were rated on average either from -4.33 to -3.33 or +4.33 to -3.33. Therefore, in the example above, only the positive fact (On All Saints Day, this melody played as the Bakers were surprised with presents.) was utilized in the experiment because it was the only item out of its triplet that met the selection criterion. There were an equal number of negative and positive facts

used. Because the emotionality ratings for facts varied, an equal number of facts from each category could not be used. Six patriotic facts, six religious facts, and four nature facts were used in each experiment set.

Procedure.

At the start of the experimental session, there was a presentation phase for the participants to learn the category-tune pairs. Participants were informed that a category would be presented before a tune was played; they were also told that another fact about the melody could be presented. Listeners were instructed to pay careful attention to the category information and were given the opportunity to ask any questions. They were not informed of an old/new recognition task. They were then allowed to start the experiment. There were three types of textual displays presented on the computer screen: category name (category), category name and neutral fact (cat+NF), or category name and emotional fact (cat+EF). The category display was on the screen for 2s before the tune started to play; the other two textual displays were on the screen for 3s because they contained more information to be read. As the tune was played, the written information remained on the screen. Once the tune was finished playing, the screen went blank and no sound was heard for 0.7s. This section took approximately 9min. A total of 48 tunes were presented during this phase; half of these melodies were presented three times; at least two tunes occurred between repetitions. Participants were divided into two groups, half of whom heard tunes from Set A in the presentation phase, and half of whom heard tunes from Set B. The utilization of these two stimulus sets allowed for counterbalancing between old and new tunes.

After the participation phase was complete, volunteers defined the final 20 words from the WAIS-R vocabulary test. They were allowed as much time as they needed to complete the vocabulary test. Immediately after the vocabulary test, participants were administered a song old/new recognition test. This test served as a measurement of explicit memory. Of the 48 melodies tested, half were heard by the participants during the presentation phase. The “new” tunes were taken from the stimulus set not utilized for the category-learning phase. This portion of the experiment was self-paced. Participants listened to each tune, made a designation by circling “old” or “new” on a sheet of paper, and then pressed a key to play the next tune. Participants had to wait until the entire tune played, but if they pressed a key quickly enough there was no delay between tunes.

Participants then completed a categorization test. All 48 tunes presented during the category-learning phase were used. As in the old/new recognition task, participants listened to each tune, made a designation by circling “religious”, “patriotic,” or “nature” on their answer sheets, and then pressed a key to play the next tune. Participants had to listen to the entire tune, but if they pressed a key quickly enough there was no delay between tunes.

When the categorization test was finished, participants were debriefed.

Results

Our first interest was how well the participants were encoding the tunes from the study phase. Analyses of performance on all recognition tasks were based upon d' scores, or the z -score of the hit rate (proportion of old items participant said were “old”) minus the z -score of the false alarm rate (proportion of new items participant said were “old”),

which show a participant's level of discrimination. A d' of 0 signifies performance at chance. Hit or false alarm rates of 0.00 were changed to 0.01 and rates of 1.00 were changed to 0.99 to prevent errors due to this approach's use of the normal curve. To test for main and interaction effects of number of presentations and association type on song recognition, we performed a 2 x 3 repeated measures ANOVA on song recognition test d' scores with number of presentations (one, three) and association type (category, cat+NF, cat+EF) as within-subjects factors. Association type did not affect d' scores, $F(2, 58) = .782, p = .620$. However, participants remembered song presented three times ($M = 2.150, SE = .123$) significantly better than songs presented once ($M = .868, SE = .137$), $F(1, 29) = 41.213, p < .001, \eta_p^2 = .587$.

To test our hypotheses about category memory, we also performed a 2 x 3 repeated measures ANOVA on categorization percent correct scores with number of presentations (one, three) and association type (category, cat+NF, cat+EF) as within-subjects factors. No significant effects were found on this analysis.

Discussion

In Experiment 1, we replicated the effect of multiple presentations on stimulus memory that has been seen in previous studies (Cary & Reder, 2002; Kornell & Bjork, 2008), on the song recognition task. However, three presentations of a tune-category pair did not strengthen participants' category memory. The absence of this effect on the categorization task lead us to question how well participants were paying attention to and encoding the song and category information.

Surprisingly, the associative fact manipulation also did not affect performance on the song recognition task or categorization task. Although it was possible that the presence of a neutral or emotional association did not have an effect on category, we had no measure definitively indicating that the participants had attended to the associative fact during the study phase. Additionally, the experiment instructions had not explicitly asked participants to encode the associative fact. Without direct evidence that the participants knew the fact, conclusions regarding the effect of associative facts could not be drawn. We chose to redesign the study before testing older adults; Experiment 2 implemented our revisions.

Experiment 2

To ensure that participants were allocating resources to encoding the associative facts, an intentional fact recognition task was added to the study design. Participants were informed of this task during the instructions for the experiment, so that they would be consciously paying attention to the facts as well as the tune-category pairs. By adding this additional task, we hoped that the participants would allocate more effort to remembering all stimuli presented during the study phase, thereby potentially leading to a stronger effect of multiple presentations.

Methods

Participants.

Twenty-eight student participants, obtained from the Psychology 100 Subject Pool, and 27 older participants, recruited from the Bucknell Institute of Lifelong Learning, were tested. Two elderly participants were removed from analysis, leaving

resulting in a total of 25 older adults used in data analysis. One admitted to misunderstanding the directions to the song old/new recognition task after experiment completion; the other had a significantly lower WAIS score than the rest of the older adults. Students were given class credit for participation; senior adults were given a movie ticket as compensation. All listeners were rated for musical experience using a musical background questionnaire, which they completed before arriving at the experimental session, to allow analysis of the relationship of experience to category memory if the two participant groups happened to differ on years of musical experience. Participant demographics can be found in Table 1.

Procedure.

The method for Experiment 2 was the same as for Experiment 1, except for the addition of the fact recognition task. Participants were told during the initial experiment instructions that they would be tested on how well they remembered the tune facts. After the categorization task, participants completed a fact recognition task. All of the 32 facts used in the study phase were on the test. Additionally, 16 new facts, taken from the original set of facts composed for the experiment, were used. Each new fact was from an old fact's triplet, so it resembled the old fact in length and general content. To continue with the example described in the "Materials" section of Experiment 1, "On All Saints Day, this melody played throughout the Baker House" was used as a new fact, because "On All Saints Day, this melody played as the Bakers were surprised with presents" was an old fact. Both neutral and emotional new facts were used.

Results

Participant Variables.

A series of *t*-tests were performed to analyze differences in group demographics (Table 1) and identify potential covariates. To correct for this build-up of familywise error rate and control for Type I errors, the overall significant level of .05 was divided by the number of *t*-tests performed on demographics (3) to yield a per-test significance level of .016. Overall, older adults had significantly more years of education, $t(26.89) = 6.06$, $p < .001$, $d = 1.71$, and higher WAIS scores, $t(51) = 4.34$, $p < .001$, $d = 1.21$. When taking into account an inequality of variances, as indicated by a Levene's test ($F = 10.76$, $p = .002$), younger and older adults did not differ on years of musical education, $t(24.92) = 2.00$, $p = .056$. The older adults' years of education and vocabulary capabilities signify that any group effect is a result of age rather than decreased education. Therefore, these factors were not used as covariates in other analyses.

Fact Recognition Task.

Data from the fact recognition task were analyzed to determine how well participants encoded the associative facts and also if the independent variables had any effect on performance. Overall, participants performed well on this task. Collapsed across groups, hit rates were high ($M = .89$, $SE = .01$) but not at ceiling. False alarm rates were low ($M = .11$, $SE = .01$), but participants were still making mistakes. To initially examine the group effect collapsed across the other variables, two *t*-tests were performed to examine age differences on total hit rate and false alarm rate. In keeping with the previously established convention to reduce familywise error across an analysis, the

significance level was designated as $.05/2 = .0125$. 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 (see Table 2).

Discrimination Scores (d').

To better examine the differences in performance, we decided to use d' scores, plotted in Figure 1. A $2 \times 2 \times 2$ repeated measures 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, $F(1, 51) = 2.78$, $p = .101$, indicating that the effect of age on hit rate was not large enough to influence d' scores. Participants' d' scores were moderately high; the lack of an age difference was not due to ceiling effects. Participants remembered an emotional fact ($M = 2.73$, $SE = .10$) better than a neutral one ($M = 2.56$, $SE = .12$), $F(1, 51) = 5.63$, $p < .001$, $\eta_p^2 = 0.10$. Also, three presentations of a fact ($M = 3.25$, $SE = .11$) benefited recognition more than one presentation ($M = 2.04$, $SE = .11$), $F(1, 51) = 405.15$, $p < .001$, $\eta_p^2 = 0.89$.

Significant interactions moderated these main effects; Figure 1 displays these effects. Interactions occurred between number of presentations and association type, $F(1, 51) = 8.53$, $p = .005$, $\eta_p^2 = 0.14$, and number of presentations and group, $F(1, 59) = 17.96$, $p < .001$, $\eta_p^2 = 0.26$. Post-hoc paired t -tests with Bonferroni corrections were used to examine these interactions. Participants remembered an emotional fact better than a neutral fact only when it was presented three times, $p < .001$. Also, younger listeners

remembered one-presentation facts better than older listeners, $p = .006$, but the age effect disappeared after three presentations.

Bias (C).

Bias was measured by *C* scores, by which we could determine how liberally or conservatively participants were responding to the fact recognition task; the more liberal a bias score, the more likely a participant is to say something is “old”. *C* scores are plotted in Figure 2. We analyzed bias scores with a 2x2x2 repeated measures 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. Older and younger participants had the same bias, $F(1,51) = .16$, $p = .693$. Participants were more conservative when recognizing facts presented once ($M = .41$, $SE = .05$) versus those presented three times ($M = -.20$, $SE = .06$), $F(1,51) = 406.62$, $p < .001$, $\eta_p^2 = .89$. A main effect of association type was also found; participants responded to neutral facts ($M = .15$, $SE = .05$) more conservatively than to emotional facts ($M = .06$, $SE = .06$), $F(1, 51) = 5.69$, $p = .021$, $\eta_p^2 = .10$.

Interaction effects were also found between number of presentations and association type, $F(1,51) = 8.50$, $p = .005$, $\eta_p^2 = .14$, and between number of presentations and group, $F(1, 59) = 18.05$, $p < .001$, $\eta_p^2 = .26$. Post-hoc paired *t*-tests with Bonferroni corrections were used to examine these interactions. Participants were more liberal on emotional fact questions than neutral fact questions only when those facts had been presented three times, $p < .001$. Although both younger and older participants

responded more liberally for facts presented three times, the younger had a larger bias difference between one and three presentations than the older, $p < .001$.

Song Recognition Task.

We analyzed the data from the song recognition task to determine if the number of presentations and association type manipulations aided in incidental memory for the tunes. We were also interested in interactions with these variables and participant age when data were collapsed across the other variables. Participants performed well on the song recognition task, but still had more difficulty recognizing the tunes than they had recognizing the associative facts. Hit rates collapsed across group were relatively high ($M = .75$, $SE = .01$), although participants were still committing misses. Participants committed more false alarms ($M = .36$, $SE = .02$) than in the fact recognition task, but the rates were still moderately low. Two t -tests were performed to examine age differences on total hit rate and false alarm rate. In keeping with the previously established convention to reduce familywise error across an analysis, the significance level was designated as $.05/2 = .025$. A mirror effect occurred; 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, $t(51) = 3.54$, $p = .001$, $d = .97$.

Discrimination Scores (d').

After establishing the presence of a mirror effect between the young and the old, d' scores were calculated to better understand the differences across variables. Figure 3 contains the plotted d' scores across variables for the song recognition task. To analyze differences in discriminations across different variable levels on the song recognition

task, we performed a 2 x 2 x 3 repeated measures ANOVA of d' scores with group (young, old) as a between-subjects factor and number of presentations (one, three) and association type (category, cat+NF, cat+EF) 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 were used to examine the nature of these interactions. Although both younger and older adults performed better with three presentations, the younger benefited more from three presentations, $p < .001$. Contrary to our hypotheses, the post-hoc analysis of the association type by group interaction revealed 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, $p = .048$.

Bias (C).

Participants' bias on the song recognition task was also analyzed using a 2 x 2 x 3 repeated measures ANOVA with group (young, old) as a between-subjects factor and number of presentations (one, three) and association type (category, cat+NF, cat+EF) as within-subjects factors. Younger and older adults had similar overall bias, $F(1, 51) = .06$,

$p = .803$. Association type did not affect bias, $F(2, 102) = .16, p = .850$; number of presentations did affect bias, $F(1, 51) = 108.29, p < .001, \eta_p^2 = .68$. Participants responded more conservatively to songs presented once ($M = -.03, SE = .06$) than songs presented three times ($M = -.57, SE = .06$).

An interaction between association type and group, $F(2, 106) = 8.59, p < .001, \eta_p^2 = .14$, was examined through a Bonferroni-corrected paired t -test. The only significant age effect by category was found for the cat+NF condition; the younger adults responded more liberally than the older adults, $p = .042$. An interaction between number of presentations and group, $F(1, 54) = 14.44, p < .001, \eta_p^2 = .68$, also occurred. The Bonferroni corrected paired t -test revealed that although younger and older listeners both were more liberal for songs presented three times, $p < .001$, there was a greater increase in liberality for the younger adults. These interactions are plotted in Figure 4.

Categorization Task.

Volunteers did not excel on this task, and in some conditions performed at chance. (Chance for this task would be 33%, because there were three answer choices. See Figure 1.) However, some conditions were above chance, so we further analyzed the data. Proportion correct was used to analyze the categorization task because it contained only old items. The categorization data were tested to examine the benefits (or lack thereof) of the different number of presentation and association type manipulations for the two age groups. The results of the categorization task are presented in Figure 5. A $2 \times 2 \times 3$ repeated measures ANOVA of percent correct was performed with group (young, old) as a between-subjects factor and number of presentations (one, three) and association

type (category, cat+NF, cat+EF) as within-subjects factors. Age did not affect overall performance, $F(1,51) = .13, p = .724$, nor did association type, $F(2,102) = .13, p = .879$. Three presentations of a tune-category pair ($M = .42, SE = .01$) led to better category memory than one presentation ($M = .34, SE = .01$), $F(1,51) = 18.81, p < .001, \eta_p^2 = .27$.

We also found a significant three-way interaction among group, number of presentations, and association type, $F(2, 148) = 6.19, p = .003, \eta_p^2 = .11$. Separate 2 x 3 repeated measures ANOVAs with number of presentations and association type as within-subjects factors were performed on the two groups. For the young, there was only an effect of number of presentations, $F(1,27) = 18.48, p < .001, \eta_p^2 = .406$. Examination of the 95% confidence intervals (CIs) for the younger group revealed that the young volunteers performed at chance for one presentation items and above chance for three presentations items. There was a significant interaction between number of presentation and association type for the older group, $F(2, 48) = 4.71, p = .014, \eta_p^2 = .16$. A Bonferroni-corrected paired t -test, coupled with the 95% CI, revealed that for one presentation, the cat+EF led to category memory above chance, compared to chance performance with the cat+NF, $p = .048$.

Discussion

The addition of the fact recognition task to Experiment 2 allowed us to analyze whether participants were attending to and encoding the associative facts along with the tune-category pairs. The high d' scores on this task indicates that participants were encoding the associative facts during Experiment 2. Additionally, it appears that the fact recognition task and small changes to experiment instructions may have encouraged

participants to allocate more effort to the task, leading to the increased number of main effects and interactions found on the song recognition and categorization tasks relative to Experiment 1. The benefit of emotion on fact recognition also serves as an indirect demonstration that the two types of facts differed, presumably on emotionality.

The overall age effect on the song recognition task, shown through the presence of the mirror effect and the younger adults' significantly higher d' scores, replicates the findings of other studies (Bartlett et al., 1995; Halpern et al., 1995) regarding age effects on music recognition. The presence of the age effect helps to indicate that we had a relatively normal sample of younger and older adults who recognized music similarly to formerly studied populations. More generally, our results, when coupled with these other findings, support the idea that musical memory is age sensitive much like other forms of memory (Monti et al., 1996; Lazzara, Yonelinas, & Ober, 2002; Park et al., 1996). Additionally, the absence of an age effect on the C scores of participant bias shows that the difference between the younger and older groups was the result of true memory differences. Contrary to cultural stereotypes about age conservatism, age had no effect on one's willingness to say yes.

The interaction between number of presentations and age indicates that although both age groups benefitted on the song recognition task from three presentations of a song, younger adults benefitted more. This may seem counterintuitive because younger adults do not normally suffer from a memory deficit that would require multiple repetitions of material. However, if the older adults did not encode each song

presentation as efficiently as younger adults, the additive effect of multiple presentations would be weaker.

Contrary to our hypotheses, no overall effect of association type occurred, nor did a three-way interaction occur among the variables. However, a two-way interaction between association type and age did appear. Association type only had an effect on the performance of older participants. In line with what we predicted, the presence of a neutral fact did not help the older adults to remember song information. Instead, the neutral fact actually hurt the discrimination of the older adults.

The absence of an association effect in the young is contrary to what we predicted. Younger adults may not have sufficiently linked the song and fact information together in memory because, given their already strong memory abilities, the fact added no encoding strength to the memory trace. Therefore, they did not benefit from the presence of an association over baseline. However, they still must encode song information and fact information during the same stimulus presentation. The young may not suffer a decline on the song recognition task in the presence of this additional fact information because they have a larger working memory capacity that can store both stimuli for encoding.

The older adults do suffer a significant decline from baseline on the cat+nf condition. Like younger adults, the older adults may not link the neutral association to the song in memory because it does not strengthen encoding; the presentation of this additional information may overwhelm their already comprised working memory capacity (Park, 1996; Craik, 2000), leading to the decline from baseline. The presence of

an emotional fact also likely puts additional strain on older adults' working memory. However, the older adults may link the emotional facts to the song-category pairs because we associate categories with emotions in the real world. This additional association may make the songs in this condition more memorable; this increased memorability counteracts the decline caused by decreased working memory and puts performance back at baseline.

This finding was also replicated in the categorization task, but only for the one presentation condition in older adults. Despite expecting younger adults' benefit from three presentations to be reduced most by the cat+EF and to a lesser extent by the cat+NF, no interaction between number of presentations and association type occurred in our younger adults.

In older listeners, we predicted that the effectiveness of three presentations would decrease when an emotional association was present. However, for the one presentation condition only, an emotional fact increased proportion correct on the categorization task to above chance relative to a neutral fact, where they performed at chance. As previously established, older adults' limited working memory may have been more burdened than younger adults' by the addition of an associative fact. They were therefore unable to successfully encode the tune-category pairs, leading to chance performance. The working memory burden was overcome on the cat+EF condition, allowing older adults to encode the tune-category pairs successfully.

On the three presentation condition, the additive strength of three encoding events for the tune-category pairs may also have helped overcome the decline on the

categorization task due to the presence of a neutral fact. Because there were more opportunities to encode each pair, both participant groups may have not needed to link the emotional fact to the song-category information. This would explain why emotion does not benefit performance for the three presentation condition in either participant group.

In addition to these by-condition analyses, overall performance on the categorization task was analyzed. Overall, participants performed much worse on the categorization task relative to the song recognition task and the fact recognition task. The increased difficulty of the task hurt younger and older participants equally when performance was collapsed across the within-subjects variables. Also, the younger adults performed at chance for the one presentation conditions and above chance in the three presentation conditions. The younger adults' performance was equated with the older adults' performance, which speaks to the task's difficulty.

To improve performance on the categorization task, future studies may wish to change how the category names and facts were presented to participants during the study phase. For this study, text was presented as black lettering on a white background. Colored font, symbols, or graphics may be added to increase the vividness of the written information and replicate the rich context that often occurs when learning song categories in the real world.

We were also interested in analyzing *C* scores; *C* scores measure bias, or how risk averse (conservative) a participant is. Not surprisingly, all participants were more conservative when answering questions about items presented once for both fact and tune

recognition tasks. The volunteers were tightening their criteria for accepting items less familiar to them; for items presented three times, participants acted more liberally and took more chances answering the recognition questions.

For the fact recognition task, younger adults gained more confidence after three presentations than the older adults did, as shown by the greater difference in bias between one and three presentations for the younger adults. On the song recognition task, younger adults were more liberal for cat+NF songs than the older adults. Younger adults may have more positive beliefs about their own memories, leading them to be more confident in their answers and more likely to take chances on answers they are not completely sure about. On the other hand, the older adults may be risk averse because of social stereotypes about their memories, or their own experiences with memory lapses. However, comparison of bias differences with participant discrimination reveals that older adults' bias may be the results of metacognitive accuracy, as the older adults were more conservative than the younger adults on items that they were remembering poorly.

General Discussion

From these experiments, we conclude that encoding of songs and their respective categories may not always benefit from associations or emotionality as other forms of memory do. The robust effect of multiple presentations found in song recognition for Experiment 1 and all tasks for Experiment 2 suggests that multiple repetitions of a melody or tune-category pair may be the only truly helpful strategy for musical memory. Musical memory may be more procedural, requiring multiple repetitions to be automatized even if one is not physically playing the tune. Procedural memory contrasts

with declarative memory, or fact-based knowledge, that can be strengthened through associations or other mnemonic devices.

Before one could state that only multiple presentations truly benefit musical category memory, the testing of the benefit of associative facts may have to be revised. The use of the associative facts, particularly emotional ones, may have created a confound due to cohort effects between age groups. Several of the facts, especially the patriotic and the religious ones, pertained to events that occurred during the older adults' lifetimes, but before the younger participants were born. Several older adults reported being emotionally affected by the facts pertaining to World War II and Vietnam. The older adults may have been able to engage these facts more than the younger adults, creating an additional benefit that could account for the lack of an age difference on the categorization task. Future studies may wish to include facts pertaining to both historic and recent events to examine if personal experience helps a person utilize an association more.

One could also build upon this study by requiring participants to generate their own self-referent neutral or emotional fact. Because participants were given the facts in the experiment, they were only able to passively use them to link a tune and category together. Participants may instead have attended to the tune-category pairs and the facts as two separate entities for two different tasks. Having volunteers generate their own facts could help them better link a melody and its category together through more active encoding.

Previous studies have applied a similar paradigm, known as the generation effect. A metaanalysis by Bertsch, Pesta, Wiscott, and McDaniel (2007) found that people remember internally-generated information better than information they are given. Other studies revealed that the generation effect in older adults is similar to that in younger adults when the generated word is semantically related to its paired word (Taconnat & Isingrini, 2004), especially when the words can be strongly associated (Taconnat, Froger, Sacher, & Isingrini, 2008). Although participants would not be generating the music and category names, it is possible that the generation of an association between the two would have the same memory benefits. Naveh-Benjamin, Brav, and Levy (2007) studied the benefits of associating two given words in a sentence and found that the aging deficit is reduced when the sentence-forming strategy is used at encoding and almost eliminated when the participants used the strategy both encoding and retrieval. If this benefit extends into the musical domain, it is possible that the generation of an association between song and category would not only increase category memory in the young, but also reduce the older adults' deficit.

In addition to the quantitative measurements obtained through recognition and categorization testing, talking with participants during the debriefing session also revealed an interesting qualitative feature of participants' performance that points to a possible reason why some experimental hypotheses were not supported. Several older participants reported after the experiment ended to having categorized tunes according to their musical qualities. Listeners identified "march"-sounding songs as patriotic, reported religious songs to sound like church-music, and nature songs as "lighter" and "twinkly."

Instead of utilizing the associations to remember each tune, participants, particularly older adults, may have used this acoustic basis as a shortcut or compensation for their memory overload. However, although this strategy makes intuitive sense, it would have been ineffective, because all tunes were randomly placed in categories independently of acoustic characteristics. Participants' reliance on this method could explain the low performance on the categorization task. Additionally, this method would not lead to success in real-life situations because music has been shown to be grouped in memory by the type of event it is associated with; listeners are often unable to group tunes by musical characteristics (Halpern, 1984).

These data have implications for how music is processed in the real world. Our study further confirmed that elderly adults' explicit memory deficit extends to the musical domain. According to a survey of over 300 elderly participants related to healthy aging, music was given the highest rating of importance to daily life, independent of age or mental status. This result was upheld by the same study 2.5 years later (Cohen, Bailey, & Nilsson, 2002). The sheer importance of music to seniors makes research into the nature of musical learning and memory valuable. This value can only be increased through further advancements into our knowledge of musical memory.

The general ineffectiveness of association types for musical category memory also represents an important finding, as it suggests that the presence of additional information may not help when encoding music. Instead, multiple presentations may be one of the only ways to sufficiently encode both tunes and their categories in memory. We can apply these findings to musical education strategies, ensuring that listeners do not

allocate effort towards encoding associations when there is no added benefit to doing so. This is particularly important for older adults, who already experience a deficit in cognitive resources.

More globally, the different levels of within-subject performance on the experiment tasks suggest that, even when encoded at the same time, people remember language-based information better than musical information. This separation indicates that manipulations beneficial to one domain of memory may not influence performance within another domain. Researchers may wish to extend the study of the relationship between memory and associations to see if the effects found in the musical domain apply to other memory domains.

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Appendix

Table 1

Demographics of Participants

Participant group	N (#males)	Age	Yrs formal education	Yrs musical education	WAIS-R ^a
Younger (Exp1)	30 (4)	18.63(0.65)	12.58(0.65)	4.75(5.72)	20.83(5.72)
Younger (Exp2)	28 (4)	18.93(0.90)	12.61(0.83)	5.18(3.12)	23.86(7.04)
Older	25 (10)	69.68(7.68)	17.08(2.72)	13.80(21.31)	31.06(4.68)

Note: Standard deviations are in parentheses.

^a Maximum score on WAIS-R = 40.

Table 2

Overall Task Performance – Experiment 2

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)
	C	.20(.07)	.26(.06)
Song 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)
Categorization	Proportion correct	.38(.01)	.38(.01)

Note: Standard errors of the mean are in parentheses. These means represent group performance collapsed across levels of the within-subjects factors.

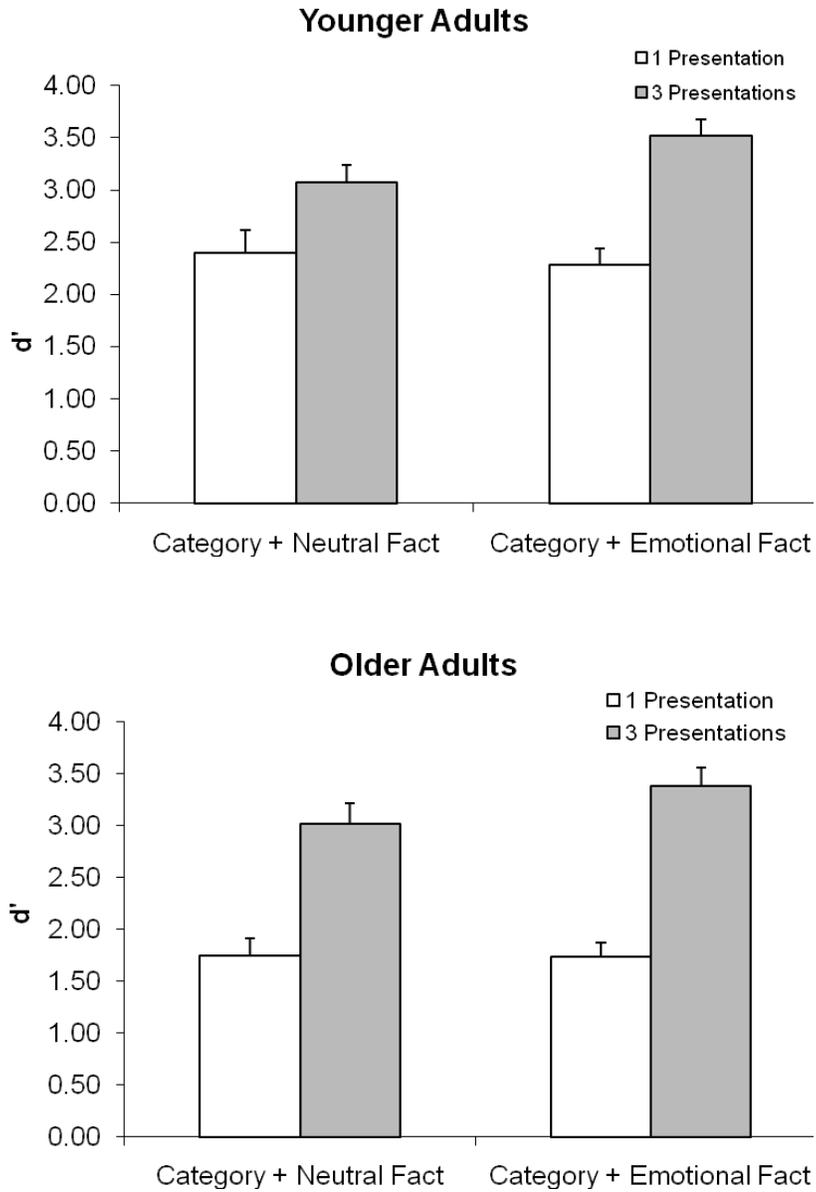


Figure 1. Discrimination scores on fact recognition in younger and older adults. Error bars represent standard errors of the mean.

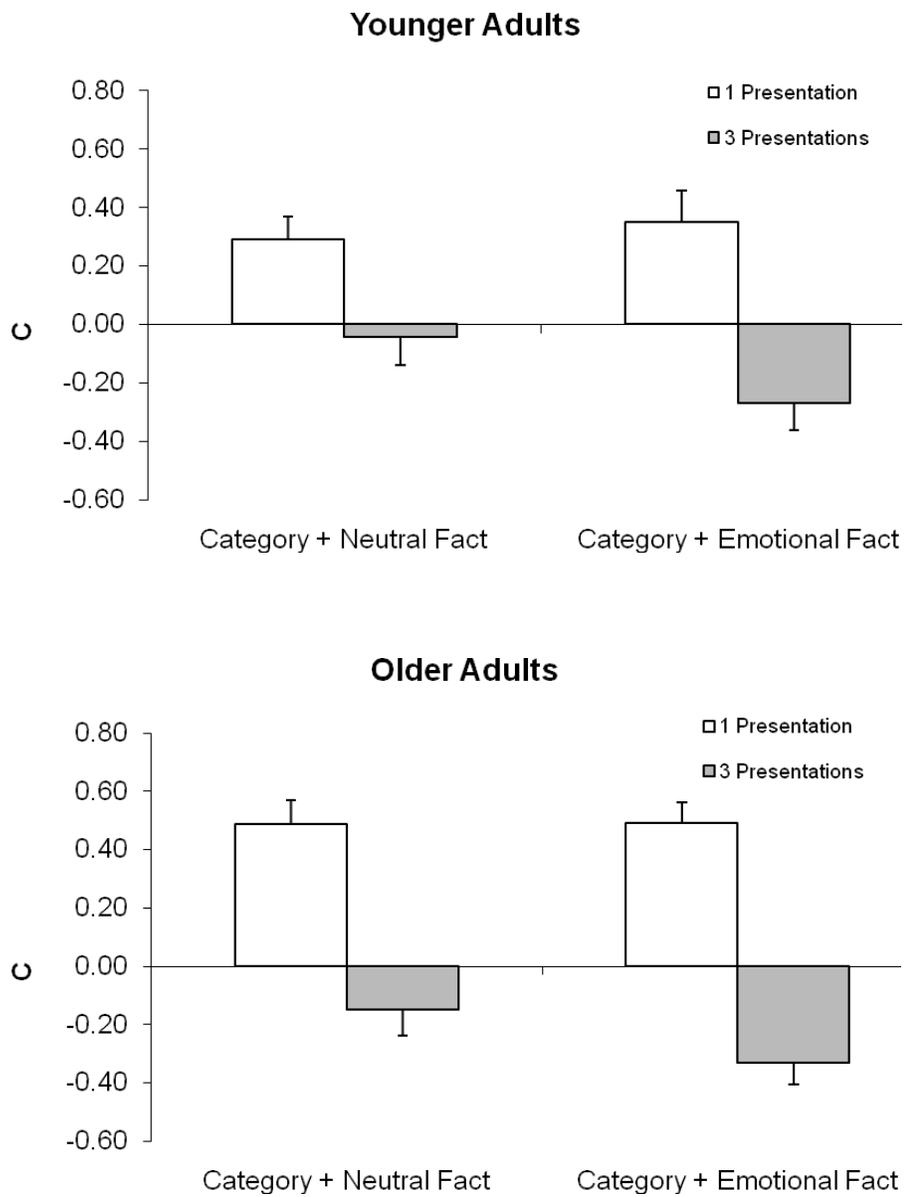


Figure 2. Bias scores on fact recognition in younger and older adults. Error bars represent standard errors of the mean.

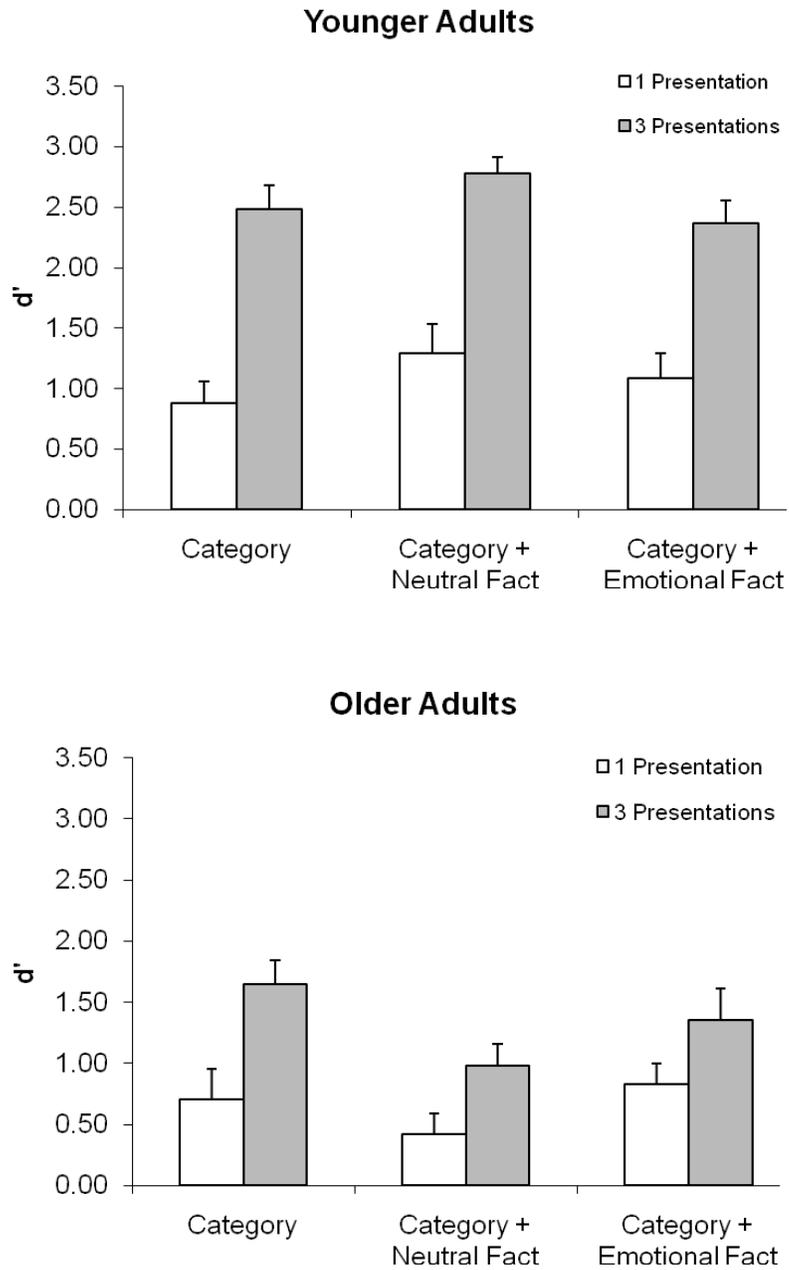


Figure 3. Discrimination scores on song recognition in younger and older adults (Experiment 2). Error bars represent standard errors of the mean.

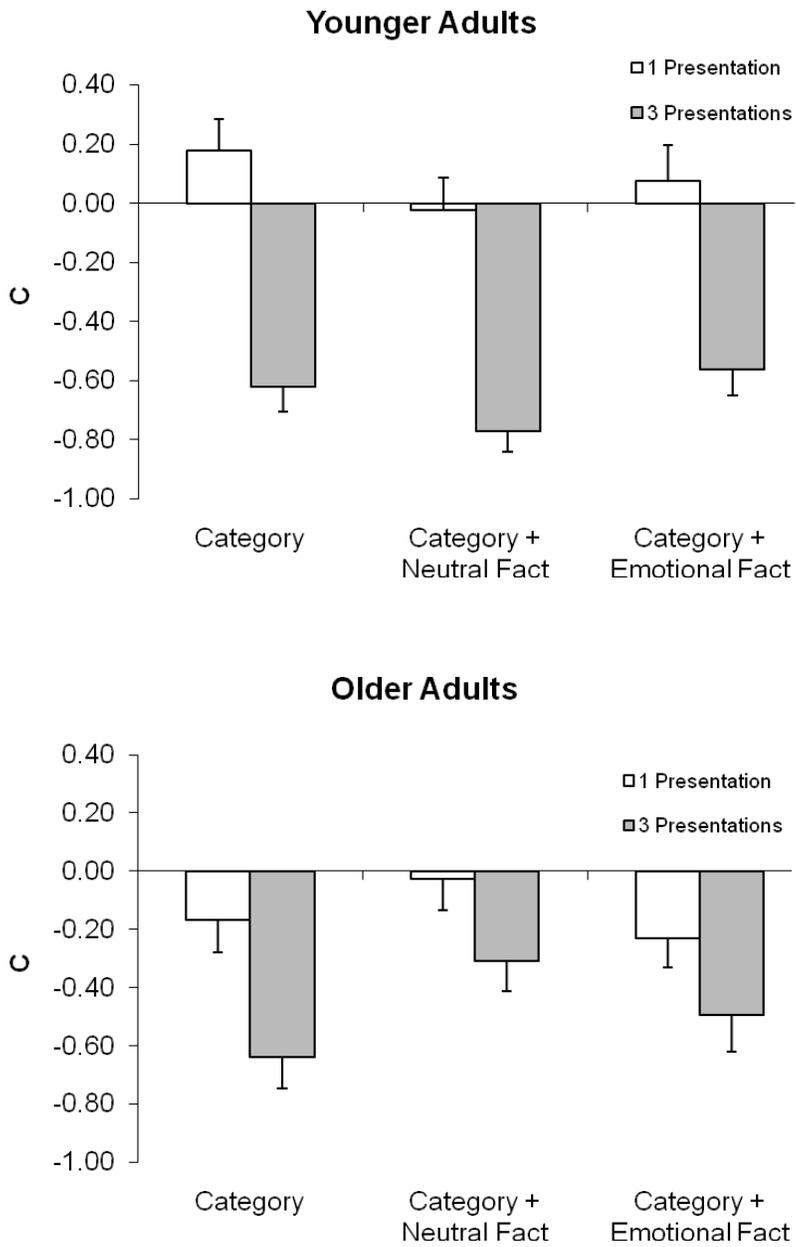


Figure 4. Bias scores on fact recognition in younger and older adults (Experiment 2). Error bars represent standard errors of the mean.

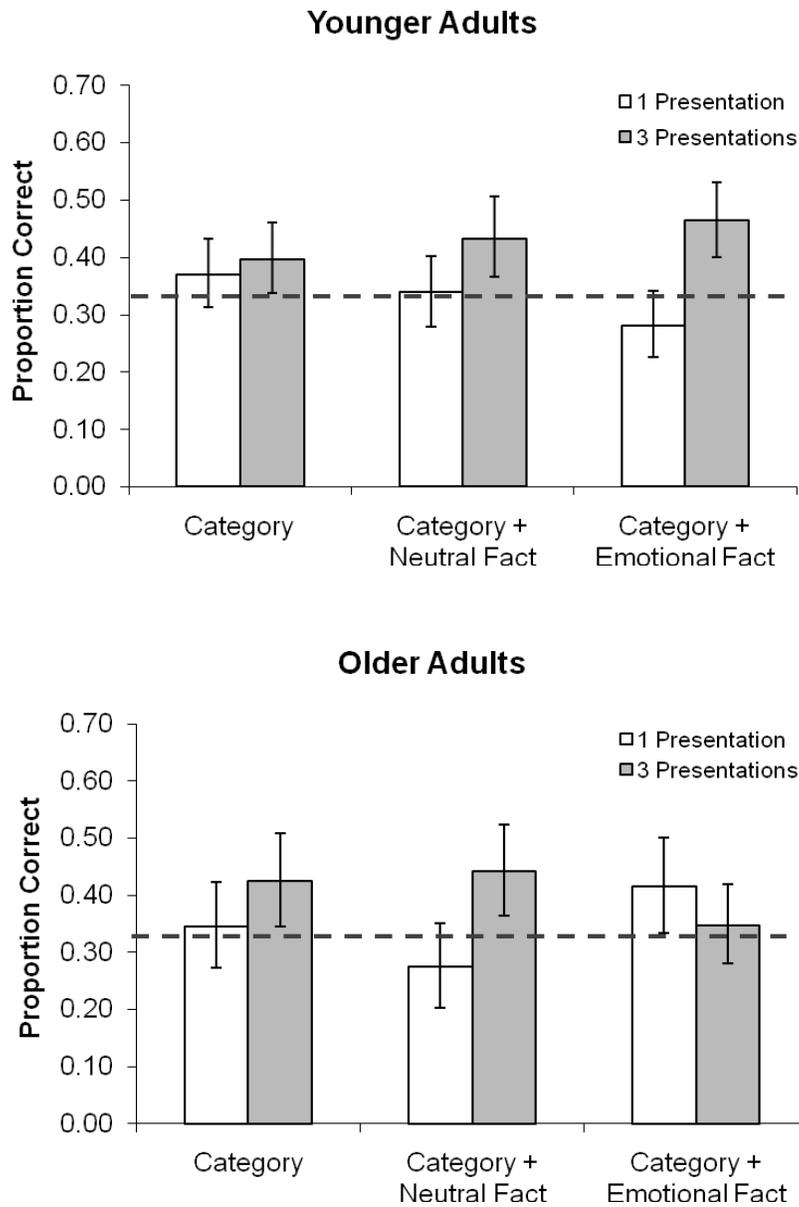


Figure 5. Category memory in younger and older adults (Experiment 2). Error bars depict the 95% confidence interval. Dashed line represents chance performance (.33).