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Effects of Perceived Emotion on Music Memory in Older and Younger Adults

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by

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A Master's Thesis

Presented to the Faculty of
Bucknell University
In Partial Fulfillment of the Requirements for the Degree of
Master of Science in Psychology

Approved: Andrea R. Halpern

Adviser : Andrea Halpern

John T. Ptacek

Department Chairperson : John Ptacek

7/6/15

(Date: month and Year)

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Abstract

Music is a universal phenomenon that reaches people of all ages. However, new music is notoriously difficult for people to learn and recognize. Some studies have shown that new items are remembered better when paired with a second piece of information, particularly if it is emotional in content. I investigated whether unfamiliar music recognition would be differentially improved by pairing unfamiliar tunes with positive versus negative descriptive emotional sentences. I also examined whether younger and older adults process these tunes or pairings differently, particularly examining the influence of emotional descriptors on tune memory. Finally, I investigated how mode and congruency with associated materials can influence tune memory. Some psychological studies suggest that as we age, we experience a positivity effect in which negative items lose their salience and positive items gain salience, and inherent memorability. However, this effect is not consistently shown and may only be specific to certain domains, with music excluded.

Overall, my first study, which tested implicit tune memory, did not yield significant effects of emotion. This led me to develop and conduct my second study in which I explicitly told participants to remember the tunes. At the conclusion of this study, I still did not find a beneficial effect of emotion. Both studies showed a better performance in the younger adults compared to the older adults, and overall better performance when given two presentations of the material versus one. My last study focused on the memorability of tunes in major mode versus minor tunes. Major tunes tend to convey a happy or positive sentiment, while minor tunes generally convey a sad or negative sentiment. I also investigated how memorable these tunes were when paired with an emotional statement that either matches or is in contrast to the musical mood. Participants had a better memory for major tunes compared to minor tunes, and showed a

trend of remembering emotionally-mismatched tunes over emotionally-matched tunes. Participants also had a better memory for tunes paired with a neutral descriptor, over an emotional descriptor, indicating that emotion is not always so beneficial in memory.

Introduction

At all points in life, we are constantly making new memories and connections. Although we retain some memories, while others fade away, and other still never make it into storage. Retained memories fall into two categories, episodic and semantic. Episodic memory consists of a moment in time, and it functions like a snapshot, including a scene of details and information about where something was encoded. This type of memory is context-dependent, and usually personal in nature. Semantic memory on the other hand is factual, and less context dependent. This type of memory stores the meaning of an item, but this meaning is not necessarily personal. As we age, we begin to see a shift in memory ability. This change is the result of lessened fluid abilities that we see in older adults. Lessened fluid ability results in a less flexible approach to memory encoding. This means that episodic memories become more difficult to construct due to an impaired ability to create a multi-faceted memory. Episodic memories also become more difficult to make because lessened fluid ability also impedes source memory, the component that gives context to a memory (Spaniol & Grady, 2012). However, a person's crystalized abilities remain intact through the aging process. Crystalized ability involves the direct storage of factual information, rather than the manipulation of information. This means that older adult can still construct semantic memories, and their store of these memories only increases with time.

The delineation between episodic and semantic memory also involves the differentiation between memory for associative and item information. Associative information entails an item and properties that are external to it, but still associated with it (Castel & Craik, 2003). An example of this is a car, and the name of its driver, and this type of information adheres to episodic encoding. Item information consists of an item and details that are internal to it, such as a cat and the color of its fur, and this type of information adheres to semantic encoding. Castel and Craik (2003) looked at how older and younger adults process and encode associative and item information. Younger adults were assigned to either a full attention or divided attention group. These participants were presented with 130 word pairs, and were either told to pay attention to the pairings, or to focus on a distractor task while viewing the words. Older adults were only assigned to the full-attention task due to a known age-related deficit in memory performance under divided attention conditions. The authors found that older adults and younger adults under divided attention showed equivalent performance in item memory. Full-attention younger adults performed best compared to these two groups, and these two groups showed worse performance with the associative information than the item information. Older adults also showed the worst performance with the associative information, even though they were in the full attention condition. Because older adults were able to give their full attention to the task, these results indicate that lower mental capacity or encoding issues may be the limiting factor, not attention, when we see lower memory performance levels in older adults.

As mentioned above, older adults show deficits in divided attention tasks when compared with younger adults. Divided attention is a process that requires a large amount of processing capacity, and as said before, processing capacity decreases with age. McDowd and Craik (1988) investigated older adult memory performance in divided attention tasks and compared their results to those of younger adults in the same task condition. They found age related-decline in complex perceptual-motor divided attention tasks. However, in simple divided attention tasks, older adults did not show this decline. These findings tell us that there is not an all-encompassing deficit as we age, but rather a gradient, and if enough support is given, performance should still be comparable to that of younger adults.

Age-related decline is not an unchangeable entity. Certain items can serve as support, boosting memory and lessening the age-related decline results. The addition of contextual information is one example of support. Naveh-Benjamin, Brav, and Levy (2007) investigated the use of context during memorization of word pairs, and its effects on subsequent memory in older and younger adults. All participants took part in intentional encoding. One third of participants were told to study the words. Another third were told to associate the two words by putting them in a sentence together. The last group was told the same instructions as the second group, and also to use these sentence during the recall test. The authors found that when participants associated two words together, memory for the words was enhanced in both older and younger adults compared to separate word presentations. They also found that using the associations during the recall test further improved performance in older adults compared to intentional encoding alone. This last result shows the benefit of adding context during encoding because participants could access the memory for two words better when told to “relate back to the sentences they had created during encoding”.

Naveh-Benjamin et al.’s (2007) study also incorporated a second supportive tactic, binding. Binding is the pairing of two disparate items together in a meaningful way to facilitate better memory performance at testing (Cohn, Emrich, & Moscovitch, 2008). Increased levels of binding allow participants to have greater access to contextual information which may improve their memory of the tunes. Cohn et al. (2008) wanted to investigate the binding hypothesis which states that older adults are impaired in binding items together at the time of encoding, but have no problem encoding the items themselves. They also wanted to know what benefit, if any is conferred when we reinstate the association environment in which participants learned the pairings. The authors tested associative memory in older and younger adults under three conditions: recall-to-reject, recall-to-accept, and full reinstatement of association environment. Recall-to-reject tests relied on participants identifying whether a recombined pair was seen earlier in order to exclude an item. Recall-to-accept tests required participants to select intact pairs seen earlier. Full reinstatement tests gave participants all possible pairs and simply asked them to identify pairs they had seen before. The authors found that older adults exhibited their worst performance in the recall-to-reject condition, and were best at the full reinstatement condition, with recall-to-accept falling in the middle. These results suggest that associations can be made, but we need to take some supportive steps to maximize memory ability.

Nashiro and Mather (2011) continued the discussion of binding by again looking at within-item versus between-item memory and incorporating the use of emotional stimuli. The authors used emotionally arousing images paired with images of shapes to see if memory performance for both categories in older adults would improve compared to words paired with neutral images. They also compared younger and older adult performance. Participants saw pairs of pictures and abstract shapes. Half were neutral pictures and the other half were emotionally arousing images (half positive, and half negative). Each participant had an association- coding session in which participants attempted to make associations between the images and a non-association-coding session in which participants passively observed the images. Then participants completed a free recall test, a location test (the subject matter of the pictures), and a pair memory test. Younger adults showed better item memory than older adults. Both groups remembered arousing pictures better than neutral ones.

The authors also found that within-item memory was poor in older adults. Intriguingly, they found that pair memory in older adults was helped by having a neutral image paired with a shape compared to an affective picture. The authors asked participants to make perceptual associations between the image and shape pairs, not semantic connections, meaning that participants were using episodic encoding. They proposed that semantic connections might improve episodic memory when using affective components. The authors also suggest that affective components have strong attractive characteristics and these can pull attention away from the pairing task, thereby impairing later memory performance.

Although Nashiro and Mather (2011) point out an issue with using emotionally arousing items, emotional arousal itself normally improves memory. If an item is too neutral, we tend to ignore it, and instead divert our attention to other more affective items. Sussman, Heller, Miller, and Mohanty (2013) investigated how arousal impacts task performance in younger adults. They used high and low-arousal positive, negative, and neutral distractors and tested performance in a divided attention task. Participants were asked to name the color of the dot superimposed over either a high or low-arousal photo, and to ignore the photo. The authors found that high-arousal negative distractors harmed task performance in younger adults. However, the also found that low-arousal negative distractors enhanced task performance compared to the positive and neutral distractors. This research tells us that affective stimuli must be controlled for arousal level and also indicates that younger adults can be sensitive to negative emotional stimuli.

Does sensitivity to affective stimuli depend on the type of emotion? Younger adults show a greater sensitivity to negative items, also known as a negativity effect, in which they pay more attention to negative items and remember them better than positive or neutral items (Spaniol, Voss, & Grady, 2008). Grühn, Scheibe, and Baltes (2007) further explored this effect in their study of recognition memory for emotional pictures. The authors asked older and younger adults to view a series of pictures and then pick out which ones they had seen in a later recognition test. Younger adults showed a definite negativity bias in which they recognized negative photos better that neutral or positive photos. Older adult participants did not show a positivity bias, meaning they did not recognize more positive photos compared to neutral photos. However, older adults did show a deficit in recognizing negative photos. This deficit leads us to the discussion of an age-related difference in processing emotional stimuli.

Older adults show a more varied response to emotional stimuli, meaning they can show the same bias as younger adults, or show an opposite effect in which their performance is harmed by the presence of negative affective items (Langeslag & van Strien, 2009). This effect is known as the positivity effect and it can occur when older adults show an enhanced response to positive items (Spaniol et al., 2008). Spaniol et al. (2008) examined the effects of emotional valence on memory for pictures, faces, and visually presented words among older and younger adults. Younger adults showed a response bias to positive items, classifying these items as new, whereas older adults showed no response bias to positive items. The authors hypothesized this result is due to an overall increase in familiarity to positive items in older adults compared to younger adults, meaning that older adults would not interpret positive items as new, but rather classify them as old. Unfortunately, older adults performed poorly by using this strategy, and this indicates a less favorable outcome of the positivity effect.

However, not all outcomes of the positivity effect are negative. In studies of music, the positivity effect can be very beneficial, leading to improved performance in the presence of pleasant tunes. Parks and Dollinger (2014) used musical excerpts that were rated as pleasant or unpleasant as they examined the positivity effect in the auditory domain. They asked young, middle-aged, and older adults to listen to these excerpts and then used a recognition test to see how many they remembered. Participants were asked to just study the tunes, just rate the tunes, followed by a surprise recognition test, or both study and rate the tunes. This means the authors were able to use incidental and intentional encoding in the same study. They found that the middle and older adults both showed the positivity effect in that they correctly recognized significantly more positive than negatively valenced musical excerpts compared to younger adults.

Lima and Castro (2011) found the positivity effect in a different manner from Parks and Dollinger. Instead of testing memory for an item, the authors examined emotion recognition in music among participants aged 17 to 84. The authors used pre-rated musical stimuli designed to express happiness, fear/ threat, sadness, and peacefulness. The authors also varied their stimuli selection on valence and arousal, making pieces that were perceived as pleasant or unpleasant, and relaxed or stimulating respectively. All pieces were played in piano timbre. The authors found that the older the participant, the less responsive he or she was to sad and scary music, but response to happy and peaceful music remained consistent in all age groups. This means that older adults were less able to detect and properly label pieces that were composed to express sadness or fear, but had no problem detecting and correctly labeling happy and peaceful music. Lima and Castro's study gets at the heart of the sensitivity changes we see as we age. Older adults show a trend in which they become less focused on negative items, choosing to devote more attention to positive items, even at a subconscious level. However, this shift in attention comes at the cost of accuracy, because our decision criterion shifts in a way that supports our emotional well-being rather than adapting to the needs of the task.

Vieillard and Bigand (2014) studied the positivity effect using a similar approach to Lima and Castro. The authors used happy, sad, threatening, and peaceful musical excerpts in their quest to discover how these excerpts would affect participants' emotions and attention to an auditory target. Participants were asked to give their opinions on how pieces of music made them fell, and to say whether the piece was one they had head during the encoding phase. They tested older and younger adults and found an intriguing positivity effect. Older adults were less emotionally affected by the threatening music and generally liked the happy music more compared to younger adults. Older adults also showed slower correct reaction times to the threatening music compared to happy music, and this pattern was not present in the younger adults. The authors suggest that the slower reaction time and lessened effect of threatening music is due to increased negative emotion regulation over the lifespan and that it can impact and impair memory for such items.

Memory impacts due to emotion are not surprising, particularly in music. Music itself is a highly emotion-laden domain. There are some pieces of music that we know by heart due either to internalized episodic memories associated with them, or because the structure of these tunes elicits a strong reaction within us. Krumhansl and Zupnick (2013) found that older adults remember music introduced in childhood, and music from early adulthood, more than music from any other time. Memory for this type of music is, again, an example of semantic memory in that it has meaning to the individual. However, new music poses a challenge for people of all age groups. Bartlett, Halpern, and Dowling (1995) confirmed this when they examined episodic memory for such tunes in older and younger adults. They also showed that older adults performed worse on a recognition task of both familiar and unfamiliar tunes when compared with younger adults. This result indicates a decline in episodic memory as we age that can be seen even in the domain of music.

Music is also an intriguing domain to study, as we all have internalized opinions and an ability to detect emotions within music. Halpern, Martin, and Reed (2008) studied how musicians and non-musicians processed major and minor tunes, as well as their ability to distinguish mode. Non-musicians showed poor performance in identifying whether a tune was major or minor. However, when asked to classify the tunes as happy or sad, the authors saw a great amount of classification improvement. The authors also found that major tunes are what we classify as our standard in music, with minor tunes classified as anomalies. This could explain why we feel discomfort when hearing minor tunes, and why they are associated with sadness or fear.

Music mood perception can also be beneficial in memory tasks. Mungan, Peynircioglu, and Halpern's (2011) research on recognition of familiar and unfamiliar tunes revealed that the task of mood judgment improved tune memory compared to all other tasks. This suggests that the perceived mood may be the most salient feature of the tunes, and that careful consideration is needed when conducting tune memory studies, especially if participants are expected to associate an item with a tune. If the item has emotional content, it could interact with the perceived mood of the tune, and lead to unanticipated memory results.

Type of encoding can also play a role in music perception and memory. Blanchet, Belleville, and Peretz (2006) tested how encoding could affect older and younger adults in a test of unfamiliar tune recognition. They compared intentional and incidental encoding for unfamiliar music by providing three groups with different sets of instructions: intentional, incidental, and divided attention, which incorporated both sets of instructions. The experimenters told participants in the intentional group explicitly to remember the tunes for later recognition, whereas experimenters told participants in the incidental group to judge if the song was a waltz or a march. The experimenters gave the third group both the incidental and intentional instructions, thereby making them the divided attention group. Older adults performed best using intentional encoding instructions and worst using the divided attention instructions, compared to the incidental encoding group. However, older adults showed greater memory in the incidental group compared to the older adults in the divided attention group. Older adults' greater memory performance in the incidental group could be the result of fewer cognitive demands, compared to the divided attention group. As a result, older adults are better able to attend to, and encode, the tunes when not having to focus on a distracting task.

Deffler and Halpern's (2011) study of the relationship between contextual information and memory for unfamiliar tunes exploited this benefit of incidental encoding. The authors combined unfamiliar tunes with different types of contextual information, and then tested recognition of tunes later in the study. They also manipulated the emotional valence of associated facts and varied the number of repetitions of pairings. The unfamiliar tunes were paired with either a category, or a category and a made-up fact about the tune. The facts were either emotional or neutral. One example of such a fact is, "This tune is played when Argentinian men go to war." This fact example contains a piece of information with a negative connotation that is not too emotionally arousing. The researchers found that older adults performed more poorly than younger adults in all conditions, and showed even greater decline with the addition of a neutral fact. However, the addition of the emotional fact restored older adult performance to older adult baseline levels. Both older and younger adults benefited from repetition of the pairings, but repetition of the pairings did not have an additive effect on older adult performance. Younger adults showed a larger benefit from the three presentations compared to older adults, but, they also showed no significant benefits from the emotional context pairing as compared to the neutral context pairing. This indicates that emotional context is important for improving memory in older adults. However, Deffler and Halpern were unable to determine whether the emotion effect was due more to positive or negative facts, or whether it was simply a general effect because valence was not controlled in this study. This motivated me to further investigate the effect they found, and led me to develop my first study, mentioned below.

Taken together, all the aforementioned studies paint an intriguing picture of how cognitive aging and general memory paradigms intersect. My goal was to combine all these diverse areas together in a study of the effects of perceived emotion on music processing in younger and older adults. Study One continued the work of Deffler and Halpern (2011) and sought to answer whether positive or negative items resulted in the effect of emotion seen in this study. I used incidental encoding and a set of pre-rated facts and tunes. Study Two continued the investigation of Study one, using intentional encoding in place of incidental encoding. Study Two also included a binding test to check for binding of the stimuli, and a rating test to make sure emotional facts were interpreted as emotional. Study Three investigated how mode and congruency with associated materials affected tune memory.

Overall, we expected to see an interaction between age and emotion in which younger adults would show a benefit for negative items, while older adults would show an opposite pattern, and potentially show a benefit for positive items. We also expected that performance in Study Two would be better compared to Study One performance. Finally, we expected that participants would remember major tunes better than minor tunes. We also expected that congruency between a tune and an emotional descriptor would lead to better memory for these tunes compared to incongruently paired tunes.

Study One

Introduction

My first study aimed to link contextual emotional valence to memory for unfamiliar tunes in older and younger adults. Contextual emotional valence, as we define it, is a piece of either emotional or neutral supportive material that gives more information about a target item. Previous experimenters in this lab investigated the relationship between contextual information and memory for unfamiliar tunes (Deffler & Halpern, 2011). They combined unfamiliar tunes with different types of contextual information, and then tested recognition of tunes later in the study. They also manipulated the emotional valence of associated facts and varied the number of repetitions of pairings. The unfamiliar tunes were paired with either a category, or a category and a made-up fact about the tune. The facts were either emotional or neutral. The researchers found that older adults performed more poorly than younger adults in all conditions, and showed even greater decline with the addition of a neutral fact. However, the addition of the emotional fact restored older adult performance to older adult baseline levels. Both older and younger adults benefited from repetition of the pairings, but repetition of the pairings did not have an additive effect on older adult performance. Younger adults showed a larger benefit from the three presentations compared to older adults, but, they also showed no significant benefits from the emotional context pairing as compared to the neutral context pairing. This indicates that emotional context is important for improving memory in older adults.

However, one factor that we are uncertain of is whether the emotional context effects were due to the specific valence of emotion, or if effects are due solely to the addition of general emotional context. The previous study did not evenly distribute the emotional facts between positive and negative. My study controlled for emotional valence in an attempt to isolate its effect on memory of paired unfamiliar tunes. This study aimed to determine whether positivity effects can occur in the domain of music, using an incidental encoding task.

The study compared younger and older adults and focused on the associated facts aspect of the previous study. These novel facts were positive, negative, or neutral in content. The neutral sentences served as a baseline measurement of associative memory. Facts were rated by older and younger adults in a pre-testing stage for emotional valence. I also controlled for fact length and equated average arousal in positive and negative statements. Sussman, Heller, Miller, and Mohanty (2013) found that high arousal negative distractors in a divided attention task, are associated with weaker task performance in younger adults, whereas low arousal negative distractors enhanced task performance compared to positive and neutral distractors. Since it is difficult to generate only high or low arousal emotional statements, we evenly distributed arousal between the two emotional conditions. To examine the beneficial effects of repeated pairings, half of the participants heard tune pairings played twice in a spaced format, while the other half of participants heard the tune parings once.

I hypothesized that overall memory for twice-presented pairings would be greater than once-presented pairings in both age groups regardless of the emotional factor. I also hypothesized an interaction of age, emotional valence, and repeated pairings, whereby older adults would recognize tunes better in the presence of positive associated facts as compared to the same condition in younger adults, and that this effect would be increased by more repetitions of the pairing. Finally, I hypothesized that younger participants would have greater memory for negatively paired tunes over positively and neutrally paired tunes compared to older adults. I hypothesized that older adults' lesser memory for negative tunes compared to younger adults is due to a lessened negativity bias in older adulthood.

Method

Participants

I recruited 40 older adults (11 males) aged 60-80 from the local area to participate in the study. These participants volunteered their time freely and were told of the general results after all the data was collected. I also recruited 43 younger adults (13 males) aged 18-30 from the Psych 100 subject pool. Younger participants were awarded credit hours toward their class participation requirement.

Materials

Sentences were developed by myself and a research assistant. We followed a careful protocol, developing the sentences in trios beginning with the neutral statement, followed by the positive and negative statements. Each trio had the same structure, and was matched in window of length and intensity of emotion within the trio. The trios contained situations familiar to both older and younger adults. Once 66 of these trios were developed, nine older and nine younger adult raters were recruited, separate from the participants mentioned above. The sentences were rated on the intensity of emotion, as well as how strongly positive or negative the sentence seemed, with a score of 0 meaning not intense, or neutral.

The emotional content was analyzed first. If a sentence had a mean score of 1.5 or above with no rater giving a negative score, the sentence was classified as positive. A sentence with a mean score below -1.5, with no rater giving a positive score, was classified as negative. The remaining sentences were classified as neutral provided that no rater gave a maximal positive or negative rating. Trios were selected for the experiment if they had the intended emotional labels for each sentence. A total of 24 trios were selected for the final experiment. A total of 48 made-up tunes were gathered from a previous experiment. These tunes were short, melodic, and in a piano timbre that was synthesized by a MIDI player. All tunes had been rated as having high musicality.

Emotion was a within-subjects variable, and number of presentations was a between-subjects variable. There were six versions of the final experiment. The first three versions contained single presentations of tune and fact pairings. Each trio was randomly assigned one song from the 48 tunes. The remaining 24 tunes were used in the tune recognition test. These remaining tunes were also used for the second three versions of the experiment which contained double presentations of pairings. In all versions, eight positive, eight negative, and eight neutral sentences were selected from different trios. This means that each trio was only selected from once for each version. From the two unused sentences within a trio, half were selected for the fact recognition test later in the study.

In the double presentation versions, the same trios were used as above, but the tunes associated with them were from the previously remaining 24 items. Each pairing's repetition was separated by at least two other pairings from its original presentation. The order of the duplicates was also randomized.

Procedure

Participants gave informed consent and then filled out a musical background questionnaire asking them what experience they had with music, their musical training, and basic demographic questions. Then participants were asked to sit in front of a monitor as a series of tunes played with facts about those tune appearing on-screen. Participants were asked to pay attention to these facts for later in the experiment. Following the study phase, participants were tested for tune recognition using a test that compiled the original 24 tunes and 24 new tunes. If the participant recognized the tune from the study phase, he or she was instructed to circle “old”, and if not, to circle “new”. Following this, the participants were instructed to fill out the WAIS vocabulary questionnaire. Then the participants completed an operation span task involving the recall of the last word of each sentence from a sequence of sentences. Finally, the participants completed a fact recognition task using the 24 facts from the study phase and 24 facts from the remaining trio sentences. Then participants were debriefed and thanked for their time.

Data Analysis

All answers from the participant answer sheets were typed into an Excel file. After this, the total hits and false alarms for each emotional category were calculated per person, and their d’ and c were calculated. All d’ and c values were then analyzed in a 2 (single, double) x 3 (neutral, positive, negative) ANOVA for both facts and tunes. If participants had a false alarm rate of 0, I corrected the score using the convention of 1/2n where n is the number of trials. If participants had a hit rate of 1, then I corrected the score using the conventional 1-1/2n.

The WAIS vocabulary questionnaires were scored according to WAIS scoring and the total score of each participant was added. The operation span task was scored by adding the total number of correctly recalled words.

I examined hit rate and false alarm rate for overall memory of facts and tunes, as well as memory for each emotional category. This secondary analysis was conducted after the initial d’ and c ANOVAs yielded no significant interactions.

Results

Demographics

Younger adults listened to an average of 2.3 hours of music per day, while older adults listened to an average of 2.26 hours of music per day, so the two groups had similar habits (Table 1). Younger adults' average age was 18.55 with an average of 13 years of education. Older adults' average age was 69.75 with an average of 17 years of education.

Table 1

Participant Information for Older and Younger Adults

	Older	Younger
	Mean (SE)	*Mean (SE)*
Age	69.75 (.86)	18.53 (.11)
Education	17 (.41)	12.83 (.11)
Hours listening	2.26 (.38)	2.3 (.18)
Vocabulary	29.9 (.90)	20.44 (.91)
Operation span	13.45 (.39)	16.23 (.40)

Vocabulary and Operation Span

The vocabulary test consisted of twenty vocabulary words and the maximum score was two points per word for a total of 40 points. Younger adults had an average vocabulary score of 20.9. Older adults had an average score of 29.9 (Table 1). In a normal population, we expect older adults to have higher vocabulary scores than younger adults, and this population follows the trend.

The operation span test consisted of 5 rounds of increasing difficulty where the participants had to keep track of increasingly larger sets of words. Each word set was unique, and at the conclusion of the word presentation phase, participants were expected to write the words from the sequence as quickly as they could. The test was not scored for the maximum set completed due to poor completion in the first sequences in both age groups. Instead we scored the total number of points with a maximum of 20. The average total of points on the operation span test was 16.18 for younger adults and 13.45 for older adults (Table 1). In a healthy population, we expect younger adults to outperform older adults in this task and these results follow this expectation.

Facts

Table 2

d' and c for Facts from Older and Younger Adults

	Single		Double	
	Older	Younger	Older	Younger
	Mean (SE)	*Mean (SE)*	*Mean (SE)*	*Mean (SE)*
d'				
Neutral	1.54 (.23)	1.50 (.22)	1.82 (.22)	2.03 (.15)
Positive	1.89 (.17)	2.19 (.17)	2.47 (.13)	2.57 (.12)
Negative	1.88 (.20)	2.35 (.13)	2.56 (.11)	2.74 (.10)
c				
Neutral	-.08 (.10)	-.17 (.09)	-.14 (.08)	-.04 (.10)
Positive	-.07 (.09)	.17 (.05)	.05 (.06)	.11 (.06)
Negative	.07 (.06)	.03 (.06)	.20 (.06)	-.00 (.04)

d'.

Overall bias-free discrimination ability was measured by d', which takes both hits and false alarms into account and accounts for response bias. (Stanislaw & Todorov, 1999). Overall performance on the fact test was high in all groups. The analysis showed a main effect of presentation in which facts were remembered better when shown twice (*M*=2.37) compared to once (*M*=1.89), *F*(1,79)=12.20, *p*=.001 (Table 2). The analysis also revealed a main effect of emotion in which positive (*M*=2.29) and negative facts (*M*=2.39) were remembered better than neutral facts (*M*=1.73), *F*(2,158)=35.63, *p*<.001.

c.

A positive value of c indicates a bias to call something new rather than old, whereas a negative c value indicates a bias to call something old rather than new. The analysis revealed a main effect of emotion in which participants were biased to say neutral facts were old (*M*=-.11) while also biased to say positive (*M*=.07) and negative (*M*=.07) facts were new, *F*(1.71,158)=8.28, *p*=.001 (Table 2). The analysis also revealed a significant interaction between age group and emotion in which older adults showed no overall bias for positive facts (*M*=-.01), while younger adults were biased to say positive facts were new(*M*=.14), *F*(2,158)=3.66, *p*=.028.

Table 3

Hit and False Alarm Rates for Facts from Older and Younger Adults

	Single		Double	
	Older	Younger	Older	Younger
	Mean (SE)	*Mean (SE)*	*Mean (SE)*	*Mean (SE)*
Hit rate	.81 (0)	.83 (0)	.87 (0)	.90 (0)
Neutral	.77 (0)	.79 (0)	.84 (0)	.84 (0)
Positive	.82 (0)	.79 (0)	.86 (0)	.86 (0)
Negative	.78 (.03)	.86 (.02)	.84 (.03)	.91 (.02)
False alarm rate	.19 (0)	.12 (0)	.07 (0)	.06 (0)
Neutral	.30 (0)	.33 (0)	.28 (.1)	.22 (0)
Positive	.23 (.04)	.11 (.01)	.11 (.01)	.09 (.02)
Negative	.18 (.03)	.13 (.02)	.07 (.01)	.09 (.01)

Hit and False Alarm Rates.

We also looked at hit and false alarm rates separately. The following example explains why separate analysis is so useful in memory studies. Older and younger adults may both have high hit rates for a particular item, but an analysis of false alarm rates may reveal that younger adults have a high false alarm rate for the item too. This would mean that the younger adults are failing to suppress their familiarity response, and responding positively to any stimuli of that type. If we see low false alarm rates and high hit rates, this means the population is doing well at the task.

My analysis of hit rates revealed a main effect of presentation in which participants had a higher hit rate when they saw the facts twice (M=.86) compared to once (M=.80), $F(1,79)=7.39$, $p=.008$ (Table 3). My analysis also revealed a significant interaction between age group and emotion, in which older adults had a higher hit rate for positive items compared to younger adults, while younger adults had higher hit rates for negative and neutral items compared to older adults, $F(2,158)=4.46$, $p=.013$.

The analysis of false alarm rates showed a main effect of presentation in which two viewings (M=.15) resulted in lower false alarm rates compared to one viewing (M=.22), $F(1,79)=8.77$, $p=.004$ (Table 3). The analysis also showed a main effect of emotion: Participants had lower false alarm rates for positive (M=.13) and negative (M=.12) facts compared to neutral (M=.28) facts, $F(1.39,158)=41.58$, $p<.001$. Finally, the analysis of false alarm rates exposed a significant three-way interaction between presentation, age group, and emotion in which older adults in the single presentation group had a much higher false alarm rate for positive facts than younger adults in the single presentation group, and younger and older adults in the double presentation group $F(2,158)=3.18$, $p=.044$. This interaction in conjunction with the high hit rate for positive items in the older adults suggests a deficit in controlling their familiarity bias for positive facts when they were not well learned. The interaction also shows us that the positivity effect seen here is both good and bad in that older adults are correctly remembering many positive items, but also falsely accepting many as well.

Tunes

Table 4

d' and c for Tunes from Older and Younger Adults

	Single		Double	
	Older	Younger	Older	Younger
	Mean (SE)	*Mean (SE)*	*Mean (SE)*	*Mean (SE)*
d'				
Neutral	.43 (.12)	.74 (.16)	.82 (.14)	1.36 (.11)
Positive	.42 (.16)	.95 (.15)	.75 (.12)	1.31 (.14)
Negative	.53 (.14)	.91 (.16)	.81 (.11)	1.60 (.17)
c				
Neutral	.10 (.07)	.15 (.06)	-.04 (.10)	.14 (.08)
Positive	.11 (.08)	.05 (.05)	-.00 (.10)	.16 (.08)
Negative	.09 (.10)	.07 (.07)	-.03 (.10)	.02 (.07)

d'.

Overall bias-free discrimination ability was measured by d'. The analysis brought out a main effect of presentation in which facts were remembered better when shown twice (M=1.11) compared to once (M=.67), $F(1,79)=15.41$, $p<.001$ (Table 4). The analysis also revealed a main effect of age group in which younger adults (M=1.15) discriminated between tunes better than older adults (M=.63), $F(1,79)=21.17$, $p<.001$. Performance in the tune task was very low, with older adults in the single presentation group scoring at or below chance, or floor performance. Younger adults showed better performance, but still were struggling with the task.

c.

A positive value of c indicates a bias to call something new rather than old, whereas a negative c value indicates a bias to call something old rather than new. My analysis of bias revealed no significant main effects or interactions.

Table 5

Hit and False Alarm Rates for Tunes from Older and Younger Adults

	Single		Double	
	Older	Younger	Older	Younger
	Mean (SE)	*Mean (SE)*	*Mean (SE)*	*Mean (SE)*
Hit rate	.55 (.03)	.63 (.02)	.65 (.03)	.71 (.02)
Neutral	.54 (.03)	.57 (.04)	.65 (.04)	.70 (.03)
Positive	.54 (.04)	.65 (.03)	.63 (.04)	.67 (.04)
Negative	.56 (.05)	.63 (.04)	.65 (.03)	.76 (.03)
False alarm rate	.39 (.10)	.31 (.03)	.37 (.03)	.23 (.02)

Hit and False Alarm Rates.

The analysis of hit rates revealed a main effect of presentation in which participants had a higher hit rate when they heard the associated tunes twice (M=.68) compared to once (M=.58), $F(1,79)=6.74$, p=.011 (Table 5). My analysis also revealed a significant main effect of age group, in which younger adults (M=.66) had higher hit rates compared to older adults (M=.60), $F(1,79)=13.04$, p=.001. Overall older adult performance in the tune task was at levels just above chance, and was close to floor performance. The analysis of overall false alarm rate also unveiled a main effect of age group in which younger participants (*M*=.27) have lower false alarm rates compared to older participants (*M*=.38), $F(1,79)=15.59$, $p<.001$. The lower hit rates and higher false alarm rates in older adults suggests that the population shows a deficit for encoding unfamiliar tunes incidentally. However, this result also suggests that this first study is too difficult for our participants, and indicates a change in approach is needed to reveal any effects if they are buried by at-floor performance

Discussion

Study one aimed to answer whether positive or negative fact context have an effect on memory for associated tunes. My first analysis focused on the manipulated stimuli, i.e. the facts alone. I found that in the facts, all participants showed a benefit from seeing the facts twice compared to once, in line with my hypotheses. I also found that positive and negative facts were remembered better than neutral facts. However, positive and negative fact memory did not significantly differ from each other, thereby collapsing the result to a superiority of memory for emotional versus neutral facts. My analysis of response bias again showed that neutral and emotional facts were processed differently. Participants were more likely to classify an emotional fact as new, meaning they find it unfamiliar, while also finding neutral facts familiar and classifying them as old. The difference between neutral and emotional facts was also expected, although I also expected to see a difference between positive and negative items in terms of overall d’ and bias. I also found a significant interaction between emotion and age group in which older adults had no bias for positive facts, while younger adults were biased to say positive facts were new. However, neutral and negative facts were processed in the same way for both age groups, meaning that only the response to positive facts showed a different pattern. Another intriguing pattern is the overall similarity between younger adults in the single presentation condition, and older adults in the double presentation condition. This indicates that the effects we are seeing are due more to performance thresholds, and once participants are above a certain threshold, meaning when they have enough support from the study design, they perform just as well as their competitors. We also see this same trend in hit and false alarm rates for the two groups.

Considering hit and false alarm rates for facts, participants performed better when given two presentations versus one presentation of the facts, showing both higher hit rates and lower false alarm rates, as I expected. I also found a significant interaction between emotion and age group in which older adults showed a higher hit rate for positive facts, whereas younger adults showed higher hit rates for neutral and negative facts. This result was somewhat expected, as older adults were anticipated to have a different response pattern to positive items than younger adults, although finding this result in the facts was not the focus of my study. The hypothesis that emotional facts would be remembered better than neutral facts was supported by the finding that all participants had lower false alarm rates for positive and negative facts compared to neutral facts. My analysis also revealed a significant three-way interaction among age group, emotion, and presentation in which older adults in the single presentation group had a much higher false alarm rate for positive facts than younger adults in the single presentation group, and younger and older adults in the double presentation group. This result was surprising because we might expect older adults to follow the same pattern, regardless of number of presentations. The interaction in conjunction with the high hit rate for positive items in the older adults suggests a deficit in controlling their familiarity bias for positive facts, but only in the single presentation group.

In tune memory, participants benefitted from two presentations of the stimuli compared to one presentation and this was expected. The analysis also uncovered a main effect of age group in which younger adults outperformed older adults in discriminating between old and new tunes. No other effects reached significance. The bias analysis revealed no significant main effects or interactions, meaning that older and younger adults performed at equivalent levels and showed the same trends in their biases. I then explored hit and false alarm rates for tune memory. Younger adults had higher hit rates than older adults, and in both age groups, having two presentations led to higher hit rates than one presentation. Younger adults also had lower false alarm rates than older adults. These results were expected, particularly because the tunes were encoded incidentally, meaning less attention was devoted to them. Older adults often show a disadvantage in these tasks, as a result of more constrained cognitive resources compared to younger adults (McDowd & Craik, 1988). However, this result also suggests that this first study is too difficult for our participants, and indicates a change in approach is needed to show effects. One way to enhance performance is to switch to intentional encoding, and this was our main manipulation in the following study. We know that our older adults are cognitively healthy by looking at the fact test data, meaning that the issue lies either in incidental encoding, associative memory, or presentation-related issues.

We were surprised by our lack of replication of Deffler and Halpern's 2011 findings. This is likely the result of cohort effects, or slight differences in study construction. Deffler and Halpern included a category with their stimuli and its possible that having the additional contextual information led to a boost in performance. Our facts were also different and it is possible that one set of facts may have been more beneficial, and imparted more emotion on the tunes than the other. Unfortunately, we do not know why the difference occurred, but moving into Study Two, we aimed to improve performance by switching encoding strategies.

Study Two

Introduction

In my first study, I found that in the single presentation condition, older adults showed floor performance in the tune recognition task, and that those in the double presentation condition were still at very low performance levels. The younger adults also showed poor performance in the tune recognition task, albeit their performance was better than that of the older adults. In all the aforementioned conditions, the tunes were encoded through incidental memory, which could explain the poorer performance. In a similar study by Blanchet, Belleville, and Peretz (2006), the authors found that older adults remembered more unfamiliar tunes when they intentionally encoded them, compared to the incidental encoding group. For this reason, the second study, used intentional encoding. In this second study, I eliminated the one presentation condition in older adults, meaning that older adults always heard the tune pairings twice. This decision came following pilot testing in which we saw floor performance again when older adults were given one presentation. However, I maintained the single and double presentation conditions for younger adults due to the expected improvement from intentional encoding.

Study Two also incorporated a binding test to ascertain whether the music and the sentences were being linked in the minds of our participants. Increased levels of binding allow participants to have greater access to the emotional context information which may improve their memory of the tunes (Cohn, Emrich, & Moscovitch, 2008). The binding test involved participants listening to tunes from the encoding phase of experiment and matching each one with the correct fact from the beginning. I also included a rating task, given right before debriefing, in which participants rated the valence of the facts from the start of the study. This task served as a check that participant assessment of fact valence aligned with the intended valence.

I hypothesized that the intentional condition should improve performance in both age groups, and that overall memory for twice-presented pairings would be greater than once-presented pairings in both age groups regardless of the emotion. I also hypothesized an interaction of age, emotional valence, and repeated pairings, whereby older adults would recognize tunes better in the presence of positive associated facts as compared to the same condition in younger adults, and that this effect would be increased by more repetitions of the pairing. However, analysis of this interaction was not possible due to the non-factorial design, but the trend was mentioned. Finally, I hypothesized that younger participants would have greater memory for negatively paired tunes over positively and neutrally paired tunes compared to older adults. I hypothesized that older adults' lesser memory for negative tunes compared to younger adults is due to a lessened negativity effect in older adulthood. Overall, I hypothesized that older adult performance would positively correlate with the amount of binding they had developed between the tunes and the facts, and that emotional facts would allow for stronger binding.

Method

Participants

I recruited 16 older adults (6 males) aged 60-80 from the local area to participate in the study. These participants volunteered their time freely and were told of the general results after all the data were collected. I also recruited 43 younger adults (30 males) aged 18-30 from the Psych 100 subject pool. Younger participants were awarded credit hours toward their class participation requirement.

Materials

I used the same stimuli from Study One. There were six versions of the final experiment. The instructions were adapted for intentional encoding of tunes and facts. Other than the intentional instructions, the tests were constructed in the same way as Study One (see Study One for more details).

I also created a binding test in which all the tunes heard in the training session were randomized in a new list heard by the participant after completing the operation span task. Each tune played only once and a number appeared concurrently on the screen. The binding test also included the list of facts from the training session, and his list was also randomized. The list had a blank next to each fact in which participants could write the number of the tune he or she thought matched with the fact. This test was self-paced, with only one listening allowed for each tune. I assessed the degree of binding by summing the number of correct pairings, and analyzed whether emotional content plays a role in binding.

Finally, I asked participants to rate the facts from the training session for emotionality. The participants were asked to rate the facts as positive, negative, or neutral. The order of the facts was once again randomized.

Procedure

Participants gave informed consent and then filled out a musical background questionnaire asking them what experience they had with music, their musical training, and basic demographic questions. Then participants were told to sit in front of a monitor as a series of tunes played with facts about those tune appearing on-screen. Participants were asked to pay attention to these facts and tunes for later in the experiment. Following the study phase, participants were tested for tune recognition using a test that intermixed the original 24 tunes and 24 new tunes. If the participant recognized the tune from the study phase they were instructed to circle old, and if not, to circle new. Following this, the participants were instructed to fill out the WAIS vocabulary questionnaire. Then the participants completed an operation span task involving the recall of the last word of each sentence from a sequence of sentences. After that, the participants completed a fact recognition task using the 24 facts from the study phase and 24 facts from the remaining trio sentences. Then, participants completed the binding test, followed by the ratings test. Finally, participants were debriefed and thanked for their time.

Data Analysis

The total hits and false alarms for each emotional category were calculated per person, and their d’ and c were calculated as in Study One. All d’ and c values were then analyzed in two separate Repeated Measures ANOVAs. The first compared younger adults in the two presentation conditions in a 2 (single, double) x 3 (neutral, positive, negative) ANOVA for both facts and tunes. The second compared participants in the double presentation condition, in a 2(older, younger) x 3 (neutral, positive, negative) ANOVA for both facts and tunes.

The WAIS vocabulary questionnaires and the operation span task were scored in the same way as in Study One. The binding test was scored for the number of correct parings. However, all participants averaged only one to two correct pairings and so the test was thrown out. Finally, the ratings test was scored for the amount of items the participants rated the same as the experimenters. All participants averaged only one or two differential ratings, and so this served as a check to verify that our stimuli contained emotional content.

I also examined hit rate and false alarm rate for overall memory of facts and tunes, as well as memory for each emotional category.

Results

Demographics

Younger adults listened to an average of 2.71 hours of music per day, while older adults listened to an average of 2.41 hours of music per day, so the two groups had relatively similar habits (Table 6). Younger adults' average age was 18.93 with an average of 13.06 years of education. Older adults' average age was 68.19 with an average of 18.93 years of education

Table 6

Participant Information for Older and Younger Adults

	Older	Younger
	Mean (SE)	*Mean (SE)*
Age	68.19 (1.78)	18.93 (.13)
Education	17.22 (.95)	13.06 (.16)
Hours listening	2.41 (.57)	2.71 (.30)
Vocabulary	30.06 (.99)	20.44 (1.04)
Operation span	14.06 (.70)	15.44 (.37)

Vocabulary and Operation Span

The vocabulary test consisted of 20 vocabulary words and the maximum score was two points per word for a total of 40 points. Younger adults had an average vocabulary score of 20.44. Older adults had an average score of 30.06 (Table 6**)**. In a normal population, we expect older adults to have higher vocabulary scores than younger adults, and this population follows the trend.

The operation span test was the same as in Study One. The test was not scored for the maximum set completed due to poor completion in the first sequences in both age groups.

Instead we scored the total number of points with a maximum of 20. The average total of points on the operation span was 15.44 for younger adults and 14.06 for older adults (Table 6). In a healthy population, we expect younger adults to outperform older adults in this task and these results follow this expectation.

Binding Test

All participants showed very poor performance in the binding test, correctly matching only one out of 24 pairings on average. For this reason, we could not analyze the data.

Facts

The following analysis required that the two younger groups be analyzed together, and the two double presentation groups be analyzed together, because older adults did not participate in a single presentation group. It is also important to note that my ratings test manipulation check confirmed that our facts contained emotional content, and that perception of this content was as intended.

Table 7

d' and c for Facts from Older and Younger Adults

	Older	Younger	
	Double	Single	Double
	Mean (SE)	*Mean (SE)*	*Mean (SE)*
d'			
Neutral	1.59 (.24)	1.59 (.24)	2.30 (.21)
Positive	2.33 (.16)	2.34 (.14)	2.58 (.14)
Negative	2.63 (.10)	2.55 (.11)	2.68 (.12)
c			
Neutral	-.23 (.11)	-.26 (.08)	-.02 (.07)
Positive	.05 (.09)	.12 (.06)	.08 (.04)
Negative	.06 (.06)	.06 (.03)	.09 (.05)

d'.

Overall bias-free discrimination ability was measured by d', which takes both hits and false alarms into account and accounts for response bias. (Stanislaw & Todorov, 1999). Overall performance on the fact test was high in all groups. The analysis revealed a main effect of presentation in younger adults in which facts were remembered better when shown twice compared to once, $F(1,56)=4.81$, $p=.032$. The analysis also showed a main effect of emotion in which positive ($M=2.43$) and negative facts ($M=2.62$) were remembered better than neutral facts ($M=1.87$), $F(2,112)=25.76$, $p<.001$.

c.

A positive value of c indicates a bias to call something new rather than old, whereas a negative c value indicates a bias to call something old rather than new. The analysis revealed a main effect of emotion in which participants are biased to say neutral facts ($M=-.16$) are old while also biased to say positive ($M=.08$) and negative ($M=.07$) facts are new, $F(1.79,112)=15.25$, $p<.001$.

Table 8

Hit and False Alarm Rates for Facts from Older and Younger Adults

	Older	Younger	
	Double	Single	Double
	Mean (SE)	*Mean (SE)*	*Mean (SE)*
Hit Rate	.87 (.03)	.87 (.02)	.89 (.02)
Neutral	.82 (.04)	.83 (.03)	.85 (.03)
Positive	.85 (.04)	.83 (.03)	.87 (.03)
Negative	.89 (.02)	.88 (.01)	.88 (.02)
False Alarm Rate	.10 (.02)	.09 (.02)	.05 (.01)
Neutral	.34 (.05)	.35 (.05)	.17 (.04)
Positive	.13 (.03)	.11 (.01)	.10 (.01)
Negative	.09 (.02)	.10 (.01)	.09 (.02)

Hit and False Alarm Rates.

We also looked at hit and false alarm rates separately. My analysis of hit rates revealed an almost significant main effect of emotion in which participants had a higher hit rate when they saw negative facts (M=.88) compared to neutral (M=.85) and positive (M=.84) facts, $F(2,112)=3.00$, $p=.054$.

The analysis of false alarm rates revealed a main effect of presentation in which two viewings resulted in lower false alarm rates compared to one viewing, $F(1,56)=5.28$, $p=.025$. A main effect of age group was also found in which younger adults had lower false alarm rates than older adults, $F(1,56)=5.03$, $p=.029$. The analysis also showed a main effect of emotion in which participants had lower false alarm rates for positive (M=.11) and negative (M=.09) facts compared to neutral facts (M=.28), $F(1.17,112)=46.38$, $p<.001$. Presentation and emotion significantly interacted: Participants had lower false alarm rates for neutral facts after seeing them twice, compared to one presentation, and this change did not occur for the emotional facts, $F(2,112)=5.89$, $p=.004$ A significant interaction between age group and emotion was also found in which younger adults had lower false alarm rates for neutral facts than did older adults, *F*(2,112)=4.09, *p*=.019.

Finally, we see that younger adults in the double presentation group had a much lower false alarm rate for neutral facts than younger adults in the single presentation group and older adults in the double presentation group, although analysis of this potential three-way interaction was not possible due to a non-factorial design.

Tunes

Table 9

d' and c for Tunes from Older and Younger Adults

	Older	Younger	
	Double	Single	Double
	Mean (SE)	*Mean (SE)*	*Mean (SE)*
d'			
Neutral	1.17 (.20)	.71 (.15)	1.74 (.14)
Positive	1.09 (.23)	.72 (.11)	1.73 (.15)
Negative	1.06 (.23)	.75 (.13)	1.72 (.17)
c			
Neutral	-.12 (.09)	.02 (.05)	.02 (.06)
Positive	-.08 (.08)	.01 (.06)	.03 (.06)
Negative	-.07 (.12)	.00 (.05)	.04 (.05)

d'.

Overall bias-free discrimination ability was measured by d'. The analysis brought out a main effect of presentation in which tunes were remembered better when heard twice (*M*=1.73) compared to once (*M*=.73), *F*(1,56)=25.85, *p*<.001. The analysis also showed a main effect of age group in which younger adults (*M*=1.73) discriminated old from new better than older adults (*M*=1.11), *F*(1,56)=8.81, *p*=.004. Overall performance in the tune task was better than that of study one. However, we do see that older adults are still less successful at this task compared to younger adults in the same condition, although older adult performance (double presentation) does exceed younger adult performance in the single presentation group.

c.

A positive value of c indicates a bias to call something new rather than old, whereas a negative c value indicates a bias to call something old rather than new. My analysis of bias revealed no significant main effects or interactions.

Table 10

Hit and False Alarm Rates for Tunes from Older and Younger Adults

	Older	Younger	
	Double	Single	Double
	Mean (SE)	*Mean (SE)*	*Mean (SE)*
Hit Rate	.73 (.04)	.63 (.02)	.78 (.02)
Neutral	.74 (.04)	.62 (.04)	.78 (.03)
Positive	.71 (.05)	.63 (.03)	.78 (.03)
Negative	.69 (.06)	.63 (.03)	.77 (.03)
False Alarm Rate	.34 (.04)	.36 (.02)	.21 (.02)

Hit and False Alarm Rates.

My analysis of hit rates revealed a main effect of presentation in which participants had a higher hit rate when they heard the associated tunes twice compared to once, $F(1,56)=17.74$, $p<.001$. A main effect of presentation was also found in the false alarm analysis such that participants had lower false alarm rates for tune they heard twice compared to tunes they heard once, $F(1,56)=16.54$, $p<.001$. The analysis of overall false alarm rate showed a main effect of age group in which younger participants have lower false alarm rates compared to older participants, $F(1,56)=11.47$, $p=.001$. No interactions reached significance.

Discussion

Study Two aimed to answer whether positive or negative fact context has an effect on memory for associated tunes, and whether intentional encoding would boost performance levels. My first analysis focused on the manipulated stimuli, i.e. the facts alone. I found that in the facts, all participants showed a benefit from seeing the facts twice compared to once, in line with my hypotheses. I also found that positive and negative facts were remembered better than neutral facts. However, positive and negative fact memory did not significantly differ from each other, thereby just showing superiority of memory for emotional versus neutral facts. My analysis of response bias again showed that neutral and emotional facts were processed differently. Participants were more likely to classify neutral facts as old, meaning they found them familiar, but emotional facts felt unfamiliar and were classified them as new. The difference between neutral and emotional facts was also expected, although I also expected to see a difference between positive and negative items in terms of overall d' and bias. The pattern seen here is the same as the pattern in Study One, although the biases in Study Two are marginally stronger. One potential explanation for this is the difference in encoding between the two tasks. In Study One, participants intentionally encoded only the facts, while incidentally encoding the tunes. This means they were able to devote all of their attention to the facts, and would be better equipped to handle the affective stimuli. In the second study, participants needed to intentionally encode the facts and the tunes. I determined that proceeding in this manner would be more effective than adding another presentation, which could lead to fatigue, or making the study within groups, which would have forced me to use less optimal fact trios. By dividing their attention between the associated items, it is possible that they became less certain with the affective stimuli, particularly if the mood of the tune did not match the emotion within the fact.

Considering hit and false alarm rates for facts, participants performed better in study two compared to study one (Table 8, Table 3). Across all conditions, participants showed very high hit rates. Participants also showed lower false alarm rates when given two presentations versus one presentation of the facts, as I expected. I also found that younger adults had lower false alarm rates than older adults. The hypothesis that emotional facts would be remembered better than neutral facts was supported by the finding that all participants had lower false alarm rates for positive and negative facts compared to neutral facts. I also found a significant interaction between age group and emotion in which younger adults showed a lower false alarm rate for neutral facts compared to positive and negative facts, whereas older adults showed higher false alarm rates for neutral facts compared to the affective facts. This result was somewhat unexpected, as neutral fact performance was expected to be poor across all age groups, although performance was still low when compared with positive and negative facts.

Presentation and emotion also interacted such that participants had lower false alarm rates for neutral facts after seeing them twice. My analysis also revealed a significant three-way interaction among presentation, age group, and emotion in which younger adults in the double presentation group had a much lower false alarm rate for neutral facts than younger adults in the single presentation group, and older adults in the double presentation group. This result was surprising because we might expect performance with neutral facts to be equally poor across all age groups as we saw in Study One (Table 3). We also see the same trend mentioned in Study One in which performance between the single presentation younger adults and the double presentation older adults was equivalent for the facts. Participants show the same hit and false alarm rates, and overall performance and biases are also equivalent. This again supports the notion of a performance threshold that once surpassed, eliminates age-related effects.

In tune memory for Study Two, younger participants benefitted from two presentations of the stimuli compared to one presentation and this was expected. The analysis also uncovered a main effect of age group in which younger adults outperformed older adults in discriminating between old and new tunes. No other effects reached significance. The response bias analysis revealed no significant main effects or interactions, meaning that older and younger adults performed at equivalent levels and showed the same trends in their biases. Participants had higher hit rates and lower false alarm rates following two presentations compared one presentation. Younger adults also had lower false alarm rates than older adults and these results were expected.

Overall performance in the tune task was much better in study two compared to study one. This result was expected because tunes were encoded intentionally, meaning participants were able to devote more attention to the tunes. However, we continue to not find any effect of emotion in tune memory. The lack of emotion effect is surprising but could be due to several factors. One such factor is a lack of apparent binding. Participants performed very poorly in the binding test, averaging one correct pairing out of 24. The binding test was designed with reinstatement of the encoding situation in mind, i.e. the most supportive testing format (Cohn et al., 2008). Participants heard the tune, and then looked at the list of facts they had seen earlier and were asked to match them. This test was difficult and relied on explicit memory, while the fact valence effect on tune memory was an implicit relation. For this reason, a binding test using implicit memory may have been better able to isolate any binding that occurred. However, the stronger performance levels in study two suggest that binding is not the issue. Another possibility stems from comments that participants made during study two about tunes and facts not matching. What participants meant is that the tunes have an inherent emotional attribution due to the mode that the tune is in., and due to randomized pairing and intentional encoding, the presence of mismatches becomes more apparent. Intentional encoding forced the participants to hear the tunes and process them as important pieces of information, rather than passively listen to them. In doing this, participants picked up on the mood of the tune, expressed by its mode. Since these tunes were paired randomly with the facts, there were cases in which the mood of the tune did not match the mood of the associated fact, causing a potential disconnect between the stimuli. Study Two was not designed to test the influence of congruency between emotional facts and the mode of a tune due to an unbalanced number of major and minor tunes. The potential influence of congruency motivated me to devise my next and final study testing for the effects of congruency on tune memory.

Study Three

Introduction

Following up on my first and second studies, I examined how the mode of the tune (major vs minor) affects the perception of the associated emotional fact. The mode of the tune is determined by its interval structure, or the spacing between its notes on a scale. Major tunes have a happy, pleasant sound to them, whereas minor tunes have a discordant, unhappy sound. Throughout my second study, participants remarked frequently that some tunes did not match the statements. This comment was not as common in the first study and is likely the result of intentional encoding, and its requirement to pay attention to both tunes and facts. Mode-fact mismatching might affect the memory of those pairings and thus could explain why I did not get the expected results from the double presentation. Mismatching was also inevitable due to my use of random assignment when constructing fact-tune pairs. I found a general trend that suggested younger adults are better at processing negatively paired tunes, although this trend did not reach significance. In order to investigate the potential effect of mismatching I used the same set of fact trios and systematically paired them with major and minor tunes constructed from a previous study. The only distinction between major and minor tunes was the scale that was used to construct them. Each tune pair had the same note contour and sounded melodically similar, but the differing scale gave them a distinctive sound as mentioned above. This was advantageous for my purposes because I could control all aspects of the stimuli, making only the scale differ, thereby allowing the determination of any effects on tune or fact memory due to incongruence.

The previous study did not take the interaction of perceived tune mood and emotional fact into account. Mungan, Peynircioglu, and Halpern's (2011) research on recognition of familiar and unfamiliar tunes revealed that an encoding task of mood judgment improved tune memory compared to several other tasks. This suggests that the perceived mood may be the most salient feature of the tunes. When conflicting information is combined, as is the case with incongruent pairings, it is possible that emotional tone of the tune is diminished, and we fail to recognize the tune. Although non-musicians may lack the ability to distinguish major and minor tunes, they are able to perceive the mood with little difficulty (Halpern, Martin, & Reed, 2008). The ability of non-musicians to pick up on mode means that my current sample need not be limited to musicians, and that my new study's results would be applicable to the aging population as a whole. The new study also allowed for an examination of the issue of divided attention, as the incongruent pairings inherently divide our attention between two opposing emotional stimuli. As previous researchers have shown, reducing divided attention load in older adults can improve their memory performance (McDowd & Craik, 1988). By incorporating two levels of emotion, we can examine interactions among emotion, tune congruence and age group which are reasonable to expect based on prior studies.

Each tune served in a congruent and an incongruent pair, but participants only experienced one of the two possible pairings during encoding and testing. Congruent pairings were a major tune with a positive statement or a minor tune with a negative statement. In addition to the positive and negative statements, I also included a small sample of neutral statements created for an earlier study. For these neutral statements, major and minor tunes were evenly distributed, and continued to serve as a baseline measure of memory. I also included another section that tested for recognition of major and minor tunes without simultaneous fact presentation during the encoding phase. This section served as a baseline measure for tune memory and allowed for an examination of the effect of mode per se on tune memory. Participants heard all of the tunes twice, regardless of whether they were in the tunes alone or the tune-fact pairing group. I chose to eliminate the single presentation condition because I wanted to give participants the best chance for recognition. For this reason, I also decided to run this study with intentional encoding instructions. The focus of Study Three was on the tunes alone, and for this reason I also did not include a fact test.

I hypothesized that overall memory for congruent pairings would be greater than incongruent pairings in both age groups. I also hypothesized an interaction of age, emotional valence, and congruent pairings, whereby older adults would recognize tunes better in the presence of positive associated facts as compared to the same condition in younger adults, and that this effect would be increased by the congruence of the tune and fact. Finally, I hypothesized that younger participants would have greater memory for negatively paired tunes over positively and neutrally paired tunes compared to older adults. I hypothesized that older adults' lesser memory for negative tunes compared to younger adults is due to a lessened negativity effect in older adulthood.

Method

Participants

I recruited 31 older adults (10 males) aged 60-80 from the local area to participate in the study. These participants volunteered their time freely and were told of the general results after all the data was collected. Two participants were excluded because one exhibited d' scores that were two standard deviations below the norm, and the other also showed very low d' and vocabulary scores. I also recruited 41 younger adults (13 males) aged 18-30 from the Psych 100 subject pool. Younger participants were awarded credit hours toward their class participation requirement.

Materials

Sentences were developed by myself and a research assistant in the previous study. The experiment had two blocks. The first block included only major and minor tunes which were compiled from tunes made previously for the lab. Each pair of major and minor tunes were complements, and followed the same melodic contour, only varying slightly in their length. As in study one and two, the tunes were also short and had been rated as melodic. We selected 12 major and 12 minor tunes and input them into SuperLab, using a fixation cross on screen during all tunes to keep participants attentive to the screen while listening to the tunes. The order of the tunes was randomized. This block of tunes was then repeated in the same order, because this gives the maximal space between repeated pairings. The first block test was developed by using the 24 tunes from the study phase and 24 new major and minor tunes from the same pool of tunes.

The second block used the sentences developed for the previous study and paired them with major and minor tunes. There were 12 positive and 12 negative facts. Half of the positive facts were paired with major tunes, creating the match condition, while the other half were paired with minor tunes, creating the mismatch condition. The same was true of the negative facts, although the minor tunes contributed to the match condition, and the major tunes contributed to the mismatch condition. Finally, I included 6 neutral facts, half of which were paired with major tunes, and half were paired with minor tunes. The order of all pairings were randomized. Then the pairings were repeated in the same order to maximize space between repetitions. The second block test was developed by using the 30 tunes from the study phase and 30 new major and minor tunes from a list of tunes made earlier for the lab.

I also had two versions of this study, in which I changed the second block. My previous study provided me with 24 fact trios of positive, negative, and neutral sentences. I decided to only use the positive and negative facts from these trios, developing the first version by taking the first 12 negative facts and second 12 positive facts. The second version was created using the second 12 negative facts and the first 12 positive facts. When pairing tunes with these facts, I made sure that each major and minor tune served equally often as a match and a mismatch tune.

After pilot testing, I found that performance in the second block deteriorated as a result of interference from Block One. In order to avoid participant fatigue and retroactive interference from tunes in Block One, I decided to split Block One and Block Two into two separate conditions. Participants only completed one of the conditions rather than both, and this dramatically improved performance in the Block Two condition.

Procedure

Participants gave informed consent and then filled out a musical background questionnaire asking them what experience they had with music, their musical training, and basic demographic questions. Then participants were asked to sit in front of a monitor as a series of tunes played. Depending on condition, participants either saw a fixation cross or a made-up fact about the tune on screen as the tune played. The instructions for both Block One and Two stated that participants only needed to pay attention to the tunes. In the case of Block Two, they were also informed that the facts on screen were there to give them more information about the tune, but that the tunes were the focus of the study. Participants were asked to pay attention to these tunes for later in the session. After the tunes were presented once, participants were given another block of study in which the tunes were repeated in the same order. Following the study phases, participants were tested for tune recognition using a test that compiled the original tunes and the same number of new tunes. If the participant recognized the tune from the study phase he or she was instructed to circle “old”, and if not, to circle “new”. Participants were also instructed to rate how confident they were in their answer on a scale of 1 (not confident) to 5 (very confident).

Following this, the participants completed an operation span task involving the recall of the last word of each sentence from a sequence of sentences. Finally, the participants were instructed to fill out the WAIS vocabulary questionnaire. Then participants were debriefed and thanked for their time.

Data Analysis

The total hits and false alarms for each emotional category were calculated per person, and d’ and c were calculated. Overall hit rates and false alarm rates were also calculated for major, minor, matched, and mismatched tunes, and the d’ and c for each category were also calculated. If participants had a false alarm rate of 0, I corrected the score using the convention of 1/2n where n is the number of trials. If participants had a hit rate of 1, then I corrected the score using the conventional 1-1/2n.

The WAIS vocabulary questionnaires and operation span task were scored as in the prior studies.

Block One and Block Two participants were analyzed separately for two reasons. The first reason was the different amount of stimuli. The second stemmed from the different types of stimuli. I ran two separate ANCOVAs for both groups, examining the role that operation span and vocabulary might play in tune memory. All other analyses were done separately

Block One

I ran a 2(older, younger) x 2 (major, minor) repeated measures ANOVA with age group and mode as the two factors, and d' and c as the dependent measures. Then, I examined hit rate and false alarm rates for major, minor, and overall tune memory.

Block Two

I ran a repeated measures ANOVA for the two age groups, with emotion d' or emotion c as the dependent variable. I then ran a repeated measures ANOVA for age and mode, with d' and c as the dependent measures. Then, I ran a second repeated measures ANOVA for age and congruency, with d' and c as the dependent measures. Finally, I examined hit rate and false alarm rates for matches, mismatches, major, minor, emotional category, and overall tune memory.

Results

Demographics

Younger adults listened to an average of 2.57 hours of music per day, while older adults listened to an average of 2.52 hours of music per day, so the two groups had similar habits (Table 11). Younger adults' average age was 19.07 with an average of 13.01 years of education. Older adults' average age was 64.32 with an average of 16.87 years of education.

Table 11

Participant Information for Older and Younger Adults

	Older	Younger
	Mean (SE)	*Mean (SE)*
Age	64.32 (.82)	19.07 (.25)
Education	16.87 (.61)	13.01 (.15)
Hours listening	2.52 (.51)	2.57 (.27)
Vocabulary	28.13 (1.37)	21.17 (.91)
Operation span	14.71 (.47)	16.51 (.38)

Vocabulary and Operation Span

The vocabulary test consisted of twenty vocabulary words and the maximum score was two points per word for a total of 40 points. Younger adults had an average vocabulary score of 21.17. Older adults had an average score of 28.13 (Table 11). As we saw in all the studies, we expected this result older adults to have higher vocabulary scores than younger adults.

The operation span test was the same as in Study One. The test was not scored for the maximum set completed due to poor completion in the first sequences in both age groups. Instead we scored the total number of points with a maximum of 20. The average total of points on the operation span test was 16.51 for younger adults and 14.71 for older adults (Table 11). In a healthy population, we expect younger adults to outperform older adults in this task and these results follow this expectation.

Confidence Ratings

The confidence ratings that participants gave were not reliable, as only some used the whole scale, while others circled an entire column of numbers, ignoring the experimenter's request to give confidence for each tune separately. For this reason, the confidence ratings were not analyzed.

Block One –Tunes alone

Table 12

d' and c for Tunes from Block One Older and Younger Adults

	Older	Younger
	Mean (SE)	*Mean (SE)*
d'		
major	1.08 (.15)	1.36(.11)
minor	1.10 (.15)	.63 (.15)
c		
major	-.21 (.13)	-.23 (.05)
minor	.23 (.12)	-.15 (.13)

d'.

Overall performance on the Block One test was good in both groups but nowhere near ceiling performance. The analysis revealed a main effect of mode in which major tunes (M=1.22) were remembered better than minor tunes (M=.86), $F(1,33)=6.34$, p=.017, although this is largely accounted for by the poor performance for younger adults in minor tune memory compared to major tune memory, and that older adults did not differ in their memory of major and minor tunes, $F(1,33)=6.83$, $p=.013$ (Table 12).

c.

A positive value of c indicates a bias to call something new rather than old, whereas a negative c value indicates a bias to call something old rather than new. The analysis revealed a main effect of mode in which participants are biased to say major tunes are old ($M=-.22$) while also showing no bias for minor tunes ($M=.001$), $F(1,33)=4.87$, $p=.034$ (Table 12). No other main effects or significant interactions were found.

Table 13

Hit and False Alarm Rates for Tunes from Block One Older and Younger Adults

	Older	Younger
	Mean (SE)	*Mean (SE)*
Hit Rate	.69 (.02)	.74 (.03)
major	.75 (.04)	.79 (.03)
minor	.62 (.04)	.66 (.04)
False Alarm Rate	.32 (.04)	.39 (.03)
major	.38 (.05)	.34 (.00)
minor	.26 (.05)	.44 (.06)

Hit and False Alarm Rates.

We also looked at hit and false alarm rates separately. My analysis of hit rates revealed a significant main effect of mode in which participants had a higher hit rate for major tunes

(*M*=.77) compared to minor tunes (*M*=.64), $F(1,33)=11.36$, $p=.002$. The analysis of false alarm rates showed a significant interaction between age group and mode in which older adults had lower false alarm rates for minor tunes than did younger adults, and this was also lower than older and younger false alarm rates for major tunes, $F(1,33)=5.51$, $p=.025$. This result shows us that younger adults appear to have more trouble with minor tunes and are unable to suppress their familiarity bias for them. We also see that older adults are unable to suppress their familiarity bias with major tunes as seen by their high false alarm rate in conjunction with a high hit rate for major tunes.

Block Two – Tunes with facts

Table 14

d' and c for Tunes from Block Two Older and Younger Adults

	Older	Younger
	Mean (SE)	*Mean (SE)*
d'		
major	.99 (.10)	1.07 (.18)
minor	.69 (.12)	.96 (.13)
congruent	.53 (.11)	.85 (.12)
incongruent	.88 (.10)	.94 (.19)
neutral	1.12 (.15)	1.30 (.21)
positive	.71 (.09)	1.03 (.14)
negative	.70 (.10)	.75 (.15)
c		
major	-.11 (.10)	-.01 (.06)
minor	.65 (.11)	.37 (.07)
congruent	.38 (.08)	.23 (.08)
incongruent	.21 (.08)	.19 (.05)
neutral	.08 (.11)	.01 (.07)
positive	.29 (.07)	.14 (.06)
negative	.30 (.09)	.28 (.04)

d'.

Overall bias-free discrimination ability was measured by d'. The analysis revealed a main effect of mode in which major tunes (*M*=1.04) are remembered better than minor tunes (*M*=.84), *F*(1,33)=4.97, *p*=.033 (Table 14). The analysis also found an almost significant main effect of congruency in which incongruent tunes (*M*=.91) were remembered better than congruent tunes (*M*=.71), .*F*(1,33)=3.81, *p*=.060. Finally, the analysis revealed a main effect of emotion in which neutral-paired tunes (*M*=1.22) are remembered better than positive (*M*=.89) and negative-paired tunes (*M*=.73), *F*(2,66)=11.37, *p*<.001. This last finding indicates that affective stimuli harmed performance in both age groups, when compared with neutral-paired tunes.

c.

A positive value of c indicates a bias to call something new rather than old, whereas a negative c value indicates a bias to call something old rather than new. The analysis showed a main effect of mode in which participants show a strong bias to classify minor tunes as new (*M*=.49), but show no bias for major tunes (*M*=-.05), *F*(1,33)=58.26, *p*<.001, and this is explained by the significant interaction between mode and age group in which older adults classify minor tunes as new more so than younger adults and more so than either age group classifies major tunes, *F*(1,33)=6.23, *p*.018 (Table 14). The analysis found an almost significant main effect of congruency in which participants had a stronger bias to classify congruently paired tunes as new (*M*=.30), more so than incongruently paired tunes (*M*=.20), *F*(1,33)=3.71, *p*=.063 Finally, the analysis found a main effect of emotion in which neutral-paired tunes (*M*=.04) were classified without bias, while positive (*M*=.21) and negative-paired tunes (*M*=.30) were classified as new, *F*(2,66)=11.52, *p*<.001. This result in conjunction with d' scores shows us that participants became less certain, and performed more poorly in the presence of affective stimuli.

Table 15

Hit and False Alarm Rates for Tunes from Block Two Older and Younger Adults

	Older	Younger
	Mean (SE)	*Mean (SE)*
Hit Rate	.53 (.04)	.62 (.03)
major	.70 (.04)	.69 (.03)
minor	.40 (.05)	.54 (.03)
congruent	.46 (.05)	.57 (.04)
incongruent	.58 (.04)	.60 (.04)
neutral	.65 (.06)	.71 (.05)
Positive	.52 (.03)	.64 (.03)
negative	.52 (.05)	.53 (.03)
False Alarm Rate	.26 (.02)	.27 (.03)
major	.36 (.03)	.32 (.04)
minor	.17 (.02)	.22 (.03)

Hit and False Alarm Rates.

My analysis showed a main effect of mode in which participants have a higher hit rate for major tunes (M=.69) compared to minor tunes (M=.48), $F(1,33)=63.83$, $p<.001$ (Table 15). I also found a significant interaction between age group and mode in which older adults have a much lower hit rate for minor tunes than younger adults and this hit rate is also lower than older and younger adults' hit rate for major tunes, *F*(1,33)=6.99, *p*=.012. The analysis found a main effect of emotion in which participants had a higher hit rate for neutral descriptor-paired tunes (*M*=.68) compared to positive (*M*=.59) and negative (*M*=.53) descriptor-paired tunes, *F*(2,66)=9.55, *p*<.001. Finally, the analysis revealed a main effect of mode in which participants had higher false alarm rates for major tunes (*M*=.34) than minor tunes (*M*=.20), *F*(1,33)=32.13, *p*<.001.

Discussion

Study Three aimed to answer whether major and minor tunes are processed differently, and whether congruency between the mood of a tune and its associated description could impact later memory performance. We first consider the Block One participants who only heard the tunes without seeing any associated facts. Overall performance in this condition was above chance for both age groups. Participants remembered major tunes better than minor tunes, and this was expected (Halpern, Martin, & Reed, 2008). The analysis also revealed an intriguing interaction between mode and age group in which younger adults performed much more poorly with minor tune discrimination compared to major tune discrimination, and lower than that of older adult discrimination ability for both major and minor tunes. This result was surprising considering the inherent mood of minor tunes is negative, and we would expect to see a negativity effect in our younger adults, and a lessened negativity effect in our older adults. One possible explanation for this phenomenon is that the minor tunes overwhelmed the younger adults, leading to poorer performance as a result of their heightened sensitivity. My analysis of bias showed a main effect of mode in which participants were biased to say major tunes were new, while showing no real bias for minor tunes overall. The response bias finding suggests that participants felt more uncertain in their memory of major tunes, and this was not entirely unexpected following comments that many of the tunes "all sounded the same".

Participants had higher hit rates for major tunes compared to minor tunes and this was expected. However, my analysis of false alarm rate showed a surprising finding in which mode and age group interacted. Older adults showed a significantly lower false alarm rate for minor tunes compared to younger adults, and this false alarm rate was also lower than the false alarm rate for major tunes for both older and younger adults. This result shows a potential benefit of minor tune processing in the older adults, although some of this benefit may be due to older adults' bias to say minor tunes are new, versus the younger adults' bias to say such tunes are old.

Overall performance in Block 2 was not nearly as good as in Block 1, but this was expected as the information given to participants was more complex. Again, as in Block One, participants were better at remembering major over minor tunes. My analysis also revealed an interesting trend in which incongruently paired tunes were remembered better than congruently-paired tunes, although this effect did not reach significance. Unexpectedly, participants remembered tunes paired with neutral descriptors better than those paired with affective descriptors. In general, we anticipate that affective stimuli should boost performance. However, the effect seen here tells us that researching with affective stimuli is not equivocal across domains and that participants may reach a performance peak after which performance suffers if given too many emotional stimuli.

Considering response bias, overall, participants were biased to classify minor tunes as new, while showing no strong bias for classifying major tunes. I also found a significant interaction between mode and age group in which older adults had a much stronger bias to classify minor tunes as new compared to younger adults, and this bias was also stronger than that of major tune classification for both age groups. In addition to the congruency discrimination results mentioned above, participants also showed a trend for classifying congruently paired tunes as new more often than they classified incongruently paired tunes, although this effect was just shy of significance. Taken together, we can see that congruence may have a modest effect on performance. That said, participants did show a main effect of emotion in which they had a strong bias to classify tunes paired with affective descriptors as new, while showing no strong response bias for the tunes paired with neutral descriptors. This finding serves as a sanity check that bias can be affected by emotional stimulus pairings.

Finally, I examined hit and false alarm rates and found a main effect of mode in which participants had higher hit rates, and lower false alarm rates for major tunes compared to minor tunes. This result was expected and was also seen in the block one participants. Older adults also had a much lower hit rate for minor tunes compared to major tunes, and compared to younger adult hit rates for major and minor tunes. Overall, participants had a higher hit rate for tunes paired with neutral descriptors over tunes paired with affective descriptors. This result was unexpected, as mentioned above, but does indicate that emotional stimuli do not always confer a benefit in memory tasks. In this case, it appears that emotional stimuli might have been too overwhelming, or that congruency effects played a role in encoding or retrieval, leading to less than optimal performance.

General Discussion

The main focus of all three studies was to examine whether the positivity effect could be isolated in context-paired musical stimuli. These musical stimuli were pre-rated as neutral tunes, meaning they contained no inherent emotion. This means that our context was designed to impart emotion onto the tunes via association. We also hoped to explore age and emotion interactions, particularly for these musical stimuli. Study One used incidental tune encoding for tunes and revealed no significant effect of emotion in either our bias or discriminability measures. We also found no effect of emotion in hit and false alarm rates for tune memory. Study Two used intentional encoding for tunes and facts and yielded similar results with no significant effect of emotion in any of our dependent measures. However, Study Three used intentional encoding for tunes, and solely focused on the tunes. This study revealed a main effect of emotion in which tunes paired with neutral descriptors were remembered better than those paired with emotional descriptors. Participants also had no response bias when classifying neutral-paired tunes, compared to their strong bias to classify affective descriptor paired tunes as new. This result was unexpected as we anticipated seeing a boost in presentation with the addition of emotional stimuli, particularly in the older adults (Deffler & Halpern, 2011). However, the fact task tells a different story.

Fact Test Revealed Significant Main Effects of Emotion

Although we did not see expected main effects of emotion in tune memory, we did see these effects in fact memory. In Study One, participants' memory for positive and negative facts did not differ significantly, but both were significantly better than memory for neutral facts.

Participants were also more likely to classify neutral facts as old, and emotional facts as new. In doing this, participants also made more errors in neutral fact memory compared to affective fact memory and this was likely due to their inability to control their familiarity bias for neutral items. This finding is also in line with that of Nashiro and Mather (2011), in which participants showed a benefit for emotional stimuli over neutral stimuli. We also found a significant interaction between age group and emotion in which younger adults were biased to classify positive facts as new, whereas older adults showed no bias.

Study Two revealed a very similar set of results. We again saw better memory for affective facts over neutral facts, and again participants were biased to classify neutral facts as old, leading to more identification errors, and emotional facts as new. However, biases were marginally larger in Study Two for neutral facts, due potentially to the type of encoding. Study Two required participants to focus on facts and tunes, and this divided attention situation likely made participants rely more heavily on their biases during testing. Participants also had higher hit rates for facts in Study Two compared to Study One. This effect is intriguing because participants in both studies were asked to focus on the facts, and only in Study Two were participants asked to also remember the tunes. The higher hit rate may be due to the increased level of attention in the second study, due to participant concentration during intentional encoding of the facts and tunes together.

Binding and its Effect on Performance

It is also intriguing that the associated tunes may have helped participants learn these facts better, particularly if the fact was congruent with the intrinsic mood of the tune, and this is a known benefit of binding (Naveh-Benjamin et al., 2007). Even though we saw no effect of emotion in tune memory for these two studies, it is possible that facts and tunes only bind together in one direction. At times, participants would become frustrated because the tune did not "match" its descriptor. The mismatch between descriptor and the mood of the tune was inevitable due to random assignment, but this comment points out that participants may have been encoding the stimuli in a fact-centric manner. This means, participants might have only bound the tunes to the facts resulting in a performance boost in the retrieval stage, but failed to bind the facts to the tunes, meaning that participants could not access the fact associations during the tune task. Had the participants said the fact didn't match the tune, then this would confer a tune-centric view of the stimuli. Another possible explanation for the higher hit rate in Study Two is the mere fact that the task was more engaging when participants had to focus on the facts and tunes. Greater levels of engagement lead to greater levels of encoding, and this can easily lead to improved memory performance in a later test. However, this effect may also be unidirectional, as also hypothesized above for the binding test. Although we see a potential boost in fact memory in the second study with the addition of tunes, this trend does not hold when tune memory is analyzed. Performance appears to show an opposite trend in tune memory, with memory worsening at the addition of facts, as seen in Study Three, and discussed below.

Study Three Findings and Interpretations

Information from Study Three revealed some important factors not considered in Study One and Two that might explain the lack of emotion-related findings. Participants remembered major tunes better than minor tunes, and also were biased to say major tunes are old, while minor tunes are new. This finding may be related to the fact we are more familiar with major tunes, and less so with minor tunes, confirming Halpern, Martin, and Reed's (2008) finding that major is our default music mode. . Study Three also showed us a nearly significant trend in which incongruently paired tunes were remembered better than congruently paired tunes. This result was surprising as we would expect that the additive nature of congruent pairings would strengthen the memory for such tunes. Instead, we see the opposite effect, potentially due to the setup of the study. Participants were asked to pay attention to the tunes for later in the study. They were also told the facts were provided to give them more information about the tunes, but that the tunes themselves were the target stimuli.

As a result, it is possible that participants shifted their strategy in the face of mismatching mood and descriptor, opting to focus on the tunes themselves. In doing this, participants would devote more resources to encoding these tunes, giving themselves a stronger encoding experience. Unfortunately, we do not have a fact-recognition test in Study Three. Had we included such a test, we might have seen poorer performance in participant affective fact recognition due to the conflicting emotional messages at encoding. In the case of tunes with neutral descriptors, participants may have simply ignored the fact and focused solely on the tunes. It is also possible that the addition of the emotional fact overwhelmed participants, thereby diminishing performance when compared to memory for tunes with neutral descriptors as suggested by Nashiro and Mather (2011).

Encoding Contributes to Performance

Type of encoding also has a major impact on performance in this series of studies. In Study One, participants encoded the facts intentionally, and the tunes incidentally. Within this study, we see good performance in the fact test, but poor performance in tune memory. Study Two required participants to encode both facts and tunes intentionally, and we expected that the two pieces of information would bind together for each pair. This study resulted in improved tune memory and equivalent levels of fact memory, compared to Study One. In Study Three, participants were asked only to intentionally encode the tunes for both Block One and Two, although it is possible they incidentally encoded the facts in Block Two. Considering all the studies, we see a benefit for intentional encoding, particularly in older adults as seen in Blanchet et al.'s (2006) study. Older adults in Study One performed at floor in tune memory. In Study Two, their performance improved, and in Study Three, participants in Block One showed good discrimination ability. In Block Two, older participants showed more of a deficit compared to Block One, and this was likely due to the addition of the facts, because it created a situation of divided attention, even if only at a subconscious level, and we know older adults show poorer performance in complex divided attention tasks (McDowd & Craik, 1988).

The addition of facts in Study Three added another level of memory support for tune encoding, but it came at the cost of older adult performance. When given two strong pieces of emotional stimuli, older participants showed poorer tune memory compared to memory for tunes paired with neutral descriptors. This result is not entirely unexpected given that older adults have impaired fluid abilities compared to younger adults. This means that older adults are less equipped to manage multiple resource-intensive stimuli, and that this could lead to encoding difficulties, or issues in retrieval (Nashiro & Mather, 2011).

Future Directions

One thing we do not know from these studies is when in life this shift occurs. Parks and Dollinger (2014) found shifts in performance as early as middle age, and their study incorporated all three types of encoding (incidental, intentional with association, and intentional alone) mentioned in these three studies. Future studies should add a third group of middle-aged adults to determine where in the lifespan the shift in criterion begins. In order to isolate whether the issue manifests during encoding or retrieval, we could use the same set of tunes for Block One and Block Two, comparing performance between the two groups for the same stimuli and also including EEG analyses. If the issue is in encoding, we should see worse performance in Block Two compared to Block One due to the additional material causing interference with memory formulation of the tunes, and see a differential EEG pattern during encoding. If the issue is retrieval, then performance in Block One will be higher than that of Block Two, but the gap should be smaller between the two groups, because the information was encoded properly, and we should see a differential pattern in the recognition phase. Future studies should also look into using a larger pool of stimuli. It is possible that our pool was just too small to pick up an effect of congruent pairing. A larger stimulus pool might allow us to have this trend reach significance, when we have a greater number of pairings to work with during study construction.

We could also use affective facts with higher emotional arousal. An example of a higher arousal emotional fact would be “Mothers in Alaska sing this song at the loss of their child”. The addition of such facts will tell us if arousal level of facts affects the congruency effect. We expect that with higher arousal facts, the congruency effect would become even stronger, due to the greater level of matching or mismatching between paired stimuli. Another idea is to conduct a study in which the number of neutral pairings is equivalent to that of pairings with affective stimuli. Studies One and Two controlled for this, and an equal number of neutral, positive, and negative stimuli were available. However, Study Three was constructed with six neutral descriptor and 12 positive and negative descriptors each. Because neutral facts served as a baseline measure in Study Three, we did not see the need to balance the number of neutral facts with that of affective facts. We also were not expecting participants to perform so well with the neutral paired tunes. For this reason, we need to confirm that the result we had is not an inflated finding, and therefore additional neutral facts should be added to the task in future studies.

We also see that the music itself can impact memory performance. We saw that major tunes are remembered better than minor tunes, and this finding supports the notion that an uneven number of major or minor tunes within a study could harm participant test performance, because one set is inherently more memorable than the other (Halpern, Martin, & Reed, 2008). This is something we could easily test by creating two additional versions of Block Two, one with more major than minor tunes, and the other with more minor than major tunes. Finally, we can test the question of directional binding by creating a series of neutral tunes with ambiguous mode and pairing them with emotional facts. We can then ask participants in a recognition test, how each tune makes them feel, and determine if the addition of emotional facts can sway the perceived emotion within the tune.

Conclusion

Overall, my study revealed that the positivity effect is not as universal as once thought. The positivity effect appears to be more isolated to tasks that present only one type of stimuli, such as words, or pictures. My study used the higher level emotional stimuli of sentences, and it is possible that processing these sentences made the tune memory task too difficult, particularly in Study One in the single presentation condition. However, participants showed excellent memory for facts in both Study One and Two, and even showed a benefit of emotion fact processing compared to neutral facts. We also found that the binding test we designed was unable to detect binding between facts and tunes, although this might have been due to the design of the test. Study Three showed us that mode is an important factor to consider when constructing a music study, and that mode can interact with the emotion of associated stimuli. Finally, we see that when asked to focus on tunes, participants perform better with the addition of a neutral descriptor compared to an affective one. This research adds to the discussion of the positivity effect in older adults, as well as the negativity effect in younger adults, and raises the question: Just how strong and valid is the positivity effect in older adults, and is there a limit to what it can be elicited by?

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