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The Positivity Effect and Auditory Recognition Memory for Musical Excerpts in Young, Middle-Aged, and Older Adults

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Socioemotional selectivity theory (Carstensen, 1995) posits that as people age, they selectively focus on positive aspects of emotional stimuli rather than negative as a way to regulate emotions. Thus, older adults remember positive information better than negative. This hypothesis has been tested extensively with visual stimuli, but less frequently with auditory stimuli, such as music. In this study, 135 young, middle-aged, and older adults heard pleasant and unpleasant musical excerpts. Participants were randomly assigned to either a study only condition, in which they heard musical excerpts and studied them for later recognition, a rate only condition, in which they rated the musical excerpts and were tested later in a surprise recognition test, or a rate and study condition, in which they both rated and studied the musical excerpts for later recognition. Older and middle-aged adults exhibited the positivity effect in that they recognized significantly more positively valenced than negatively valenced excerpts in contrast to young adults. This finding provides further support for socioemotional selectivity theory (Carstensen, 1995, 2006; Reed & Carstensen, 2012) in the domain of aural processing.

Keywords: socioemotional selectivity theory, positivity effect, aging, music, recognition memory

The term "positivity effect" was coined to describe older adults' preferential processing of positive information over negative information in visual memory recognition studies (Reed & Carstensen, 2012). The socioemotional selectivity theory (Carstensen, 1995) postulates that, as a result of changes in motivation toward future goals, emotional priorities change over the life span. Young adults and those who perceive no limitation of time are motivated to expand their horizons in terms of acquiring information and broadening their number of social contacts. Older adults and those who perceive limitations in their time remaining are motivated to focus on the present and narrow their social contacts to meaningful relationships with family and close friends (Carstensen, 2006). The shift in goals contributes to differences in how information is processed. Socioemotional selectivity theory predicts that because of this shift over time, older adults will prefer processing positive information rather than negative information in contrast to the preferences of younger adults (Reed, Chan, & Mikels, 2014).

The positivity effect has been widely demonstrated in memory recognition studies using visual stimuli (Charles, Mather, & Carstensen, 2003; Mather & Carstensen, 2003; Mickley, Steinmetz, Muscatell, & Kensinger, 2010; Mikels, Larken, Reuter-Lorenz, & Carstensen, 2005; Spaniol, Voss & Grady, 2008). The positivity effect in terms of emotion perception by older adults has also been found in studies using auditory stimuli, specifically music. Laukka and Juslin (2007) examined age-related differences in emotion recognition as expressed in speech and music. Older adults were less accurate in their recognition of negative emotion expression than positive for speech and music stimuli. Lima and Castro (2011) further examined age-related changes in emotion recognition expressed by music. Participants ranging in age from 17–84 years were asked to listen to musical excerpts portraying happiness, sadness, scariness, and peacefulness. They were then asked to rank how much each excerpt represented each emotional quality. An age-related difference was noted, with older adults not as responsive to sad and scary music as young adults. No age-related difference was noted for happy and peaceful music. Vieillard, Didierjean, and Maquestiaux (2012) examined age-related differences in determining complexity in the perception of valence and arousal while listening to excerpts of film music. Older adults did not rate peaceful and threatening excerpts as significantly different. The older adults may not have found the threatening music to be stimulating and may have paid less attention to negatively arousing stimuli as a way of controlling their emotional responses to the music (Vieillard et al., 2012). In sum, the results of studies using visual as well as auditory stimuli provide support for the positivity effect because older adults were more responsive to stimuli representing positive emotions than they were to stimuli representing negative emotions. The goal of the present study was to examine the presence of the positivity effect in recognition memory for music.

There were three objectives for the current study. The first objective was to investigate age-related differences in the interaction between emotion and cognition based on recognition of emotionally valenced musical stimuli. The precise goal of the study was to examine if the positivity effect based on the socioemotional selectivity theory (Carstensen, 1992) would be generalized to recognition memory in an auditory domain, specifically music. Young, middle-aged, and older adults listened to carefully chosen musical excerpts for later recognition memory, in addition to

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completing cognitive tests and measures of affect. We hypothesized that if older adults in the sample demonstrated the positivity effect for recognition memory of musical excerpts, they would recognize proportionally more of the pleasant excerpts than they would the unpleasant. Young adults would be expected to recognize proportionally more unpleasant excerpts than pleasant excerpts. Eschrich, Münte, and Altenmüller (2008) examined recognition for musical excerpts based on valence, arousal, and emotional intensity across two sessions, one week apart, but did not investigate age-related differences as was done in the current study.

The second objective was to explore differences in recognition memory for musical excerpts based on instructions. The current study was based on a study designed by Blanchet, Belleville, and Peretz (2006) which examined age-related differences in memory for melodies across three conditions of intentional encoding, a judgment + intentional encoding, or a judgment only condition. The judgment included deciding whether the tune was a march or a waltz. No age-related differences were observed in the intentional encoding condition, but older adults' performance in the judgment + intentional encoding condition was compromised, as reflected in their having difficulties making a judgment. Older adults in the judgment only condition were able to make correct judgments regarding the rhythm of the melodies but performed less accurately than the young adults in the recognition phase of the study. Blanchet et al. (2006) suggested older adults had difficulty dividing their attention between making the judgment and studying the melodies for later testing. They proposed that making an emotional rating about melodies might enable more efficient encoding of the melodies for later recognition. Therefore, participants in the current study were randomly assigned to one of three conditions in which encoding demands differed: the study condition, in which they were asked to listen to the excerpts and try to remember them for later recognition testing; the rate condition, in which they were asked to rate the musical excerpts based on whether they enjoyed the excerpt (found it pleasant) or disliked the excerpt (found it unpleasant); or the rate and study condition, in which they were asked to rate the excerpts as well as to study the excerpts for later testing. The recognition testing phase of the study was unexpected by those in the rate condition. Based on the findings from Blanchet et al. (2006), we hypothesized that all participants in the study condition would recognize more excerpts than those in the other two conditions because their attention at encoding would be focused on memory, that young participants in the rate and rate and study conditions would recognize more unpleasant excerpts than pleasant excerpts, while older participants would recognize more pleasant excerpts than unpleasant (i.e., the positivity effect). Middle-aged participants were included to explore if the positivity effect would also be evident in middle adulthood.

The age-related positivity effect has also been examined under varied instruction conditions. Socioemotional selectivity theory predicts that the positivity effect will be reduced when the goals of the study conflict with the chronically activated goal of emotion regulation (Mather & Carstensen, 2005; Reed & Carstensen, 2012). For example, Hess, Popham, Dennis, and Emery (2013) found evidence in support of the positivity effect for older adults who were shown positively and negatively valenced images and given different viewing instructions. When more demands were placed on the participants (i.e., they were told there would be a memory test later), older adults did not display a positivity effect. However, under conditions in which the viewing instructions were to watch as if watching on TV or as if they or someone close to them were experiencing the situations conveyed, older adults recognized more of the positively valenced images than the negatively valenced, demonstrating the positivity effect. The content of the stimuli may have differentially influenced the positivity effect normally demonstrated by older adults by disrupting the employment of normal top down goal-driven processing. This finding supports the hypothesis of the socioemotional selectivity theory (i.e., changes in goals should reduce the positivity effect for older adults). The current study used three conditions to further examine whether differing instructions would disrupt the positivity effect for older adults in aural processing as it has been demonstrated in the domain of visual processing.

The third objective was to examine age-related differences in the two cognitive processes of recognition memory, remembering and familiarity (Yonelinas, 2002), for musical stimuli. Familiarity is a faster process than remembering and involves a sense of recognition but without recall of the contextual details. Remembering is a slower process and involves recalling the contextual details for a recognized event (Yonelinas, 2002). Tulving (1985) equated recollection with episodic memory or context of event such as location, time, and associated emotions, and familiarity with semantic memory, memory for facts and concepts acquired over time, or a feeling of familiarity with the event. Tulving further distinguished between episodic and semantic memory with the concept of "mental time travel." Episodic memory consists of mentally traveling back in time to the event or "remembering." Semantic memory does not include the mental time travel component but does include familiarity with the event or "knowing." Because episodic memory is more vulnerable to brain pathology and age-related decline (Tulving & Markowitsch, 1998), it is important to examine age-related differences in episodic memory for auditory stimuli as well as visual stimuli. For the purposes of the current study, knowing was assumed to be associated with a feeling of "familiarity" with the excerpt. In other words, the participant might know or think they might have heard the excerpt earlier during the session, but remembering the excerpt also included recalling something he or she thought or felt during the first hearing. For example, one participant stated, "I remember thinking that music sounded like something from the TV show 'Big Valley' and, therefore, pressed 'r' for 'remember.'" This distinction was explained in detail to the participants and they were asked to repeat their understanding of the difference between remembering and knowing to the researcher. An age-related difference in the number of endorsements for remember responses compared with know responses was expected, with younger adults endorsing remember responses more frequently and correctly than older adults, who were expected to exhibit more difficulties in the cognitive process of remembering by incorrectly endorsing remember responses and having more remember false alarms. Our hypothesis for this third objective was that if our older adult sample was representative of the general older adult population, they would incorrectly endorse a greater number of remember responses and produce a larger number of remember false alarms for musical (auditory) stimuli. Previous studies have employed memory for word lists and visual information as stimuli and have generated similar results (Boywitt,

Kuhlmann, & Meiser, 2012; McCabe, Roediger, McDaniel, & Balota, 2009). The remember/know procedure has been used to examine recognition memory for melodies (Gardiner, Kaminska, Dixon & Java, 1996), but not to examine age-related differences in recognition memory performance.

Method

Participants

The 135 participants in this study ranged in age from 17 to 92 years. Demographic information for the sample is presented in Table 1. Young participants were drawn from a large introductory and an upper level psychology course. Middle-aged and older participants were drawn from the surrounding community, and were recruited by word of mouth, postings on social media, and by direct approach on the part of the researchers. Young and middle-aged adults were also recruited from a nursing program at a local community college. Participants from the psychology courses and the nursing program received course credit for participation. Community participants received a gift card to a local retailer for their participation.

Measures

St. Louis University Mental Status Exam. The St. Louis University Mental Status Exam (SLUMS; Tariq, Tumosa, Chibnall, Perry, & Morley, 2006) was used to screen for mild cognitive impairment and dementia in participants over 65 years of age. The average score was 27.42 and the range was 24–30, indicating all older participants were within the normal range.

Hearing acuity. Hearing acuity was assessed with both a self-report measure based on questions from the American Speech-Language-Hearing Association (American Speech-Language-Hearing Association (2013; www.asha.org) and a digital medical hearing screener: Redding Medical Universal Hearing Screener, #9360, for 40 dB at 500, 1000, 2000, and 4000 Hz. As expected, older adults demonstrated more difficulties with hearing at higher frequencies than the young and middle-aged groups but all had hearing abilities within an acceptable range consistent with the general population (Sprinzl & Riechelmann, 2010). While van Boxtel et al. (2000) noted that mild hearing impairment can impair performance on verbal memory measures, older participants in the current sample performed well on the Digit Span Forward and Backward subtests (Wechsler Adult Intelligence Scale—Revised; Wechsler, 1981), which may be considered a test of verbal memory because digits were presented vocally and participants were asked to repeat them first in the same order as presented and next in reverse presentation order. In addition, musical excerpts were presented using orchestral instruments of varying frequencies, based on the assumption that older adults would find it easier to identify excerpts using many instruments with a wide range of frequencies more efficiently than excerpts consisting of a solo instrument with a more narrow frequency range (e.g., the frequency range for solo violin is 200–20K hertz. By adding a cello and a string bass the range increases to 60–20K hertz; Independent Recording Network, 2014). Each participant wore noise-cancelling

Table 1
Sample Characteristics

	Total (*n* = 135) Age range: 17–92 years			
Variable	Young (*n* = 54, 40%)	Middle-aged (*n* = 40, 29.6%)	Old (*n* = 41, 30.4%)	Total
Age				
Mean (*SD*)	22.1 (3.7)	49.5 (7.6)	74.5 (7.1)	
Range	17–34	35–64	65–92	
	N (%)			
Gender				
Male	19 (50)	10 (26)	9 (24)	38 (28)
Female	35 (36)	30 (31)	32 (33)	97 (72)
Education				
High school	4 (7)	2 (5)	10 (24)	16 (12)
Some college	46 (85)	19 (48)	6 (15)	71 (53)
College degree	4 (7)	11 (20)	9 (22)	24 (18)
Some graduate school	0	0	2 (5)	2 (1)
Graduate/Professional school	0	8 (20)	14 (34)	22 (16)
Marital status				
Single	49 (91)	6 (15)	0	55 (41)
Married	4 (7)	29 (73)	33 (81)	66 (49)
Divorced/Separated	1 (1.9)	4 (10)	0	5 (3.7)
Widowed	0	1 (2.5)	8 (6.7)	9 (6.7)
Race				
African American	8 (14.8)	0	1 (2.4)	9 (6.7)
Asian	4 (7.4)	1 (2.5)	1 (2.4)	6 (4.4)
Hispanic Latino	1 (1.9)	0	0	1 (0.7)
White/Caucasian	41 (75.9)	38 (95)	39 (95.1)	118 (87.4)
Other	0	1 (2.5)	1	

head phones during the presentation of the musical excerpts, was instructed on how to use the volume control for the head set, and queried as to whether they could hear the music at several points during the testing session.

Measures of affect. Participants completed the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1998) as a measure of their mood state at time of testing. Participants also completed the Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977) and the Future Time Perspective Scale (Carstensen & Lang, 1996) to assess future expectations and perceived limitations on time. Results based on the affect measures are reported in Table 2. Significant differences in age groups were noted for the Positive subscale of the PANAS (Watson et al., 1998), with younger adults scoring significantly lower on this measure than older adults. For the portion of the PANAS that measured negative affect, young and middle-aged adults exhibited more negative affect than older adults in this sample. There were no significant age group differences or differences by condition on the CES-D (Radloff, 1977). In addition, young and middle-aged adults in this sample indicated they were more optimistic about the future than older adults, based on scores from the Future Time Perspective Scale (Carstensen & Lang, 1996).

Cognitive measures. The Verbal Paired Associates Test (VPAT; Uttl, Graf, & Richter, 2002) and the Digit Span Forward and Backward subtests of the Wechsler Adult Intelligence Scale—Revised (Wechsler, 1981) were administered to assess episodic memory, short-term memory, and working memory, respectively, and are reported in Table 3. Normal age-related changes in scores for the VPAT were noted with young adults scoring significantly higher than older adults at Times 1, 2, and 3. The middle-aged group also scored significantly higher than the older group at Times 2 and 3. No significant differences were noted across groups for the Digit Span Forward and Backward subtests (all *p*s $> .05$).

Musical stimuli and recognition memory test. The musical stimuli for the current study were excerpts chosen from the Eerola and Vuoskoski (2011) stimulus set. This stimulus set consists of film music, which provides powerful emotional cues during movie scenes. Eerola and Vuoskoski (2011) limited the set to music composed within the last 3 decades (1976–2006) in order to construct a uniform list of stimuli. They assembled a panel of 12 expert musicologists who were given five different movie sound tracks and asked to find five examples of the discrete emotions of happiness, sadness, fear, anger, surprise, and tenderness, as well as the dimensions of positive and negative valence, high and low tension arousal, and high and low energy arousal. The musicologists listened to all of the audio tracks and rated each on perceived emotion (i.e., the emotion conveyed by the musical excerpt). The finalized stimulus set was based on consensus across the panel members and provided an effective means to measure discrete emotions. Cronbach's alpha for consistency ratings between the panel members ranged from .66 to .93.

Fourteen excerpts from the finalized stimulus set which were rated as pleasant or unpleasant (Eerola & Vuoskoski, 2011) were chosen as representative of valence in a systematic and deliberate process. This set served as the stimulus set for the current study. The first author, who has training in music including a bachelor's degree in music education, listened to each of the excerpts from the Eerola and Vuoskoski (2011) set and discarded those using solo instruments (e.g., piano) to present the main theme. Next, excerpts portraying specific recognizable styles of music (e.g., '50s pop), folk songs (e.g., "Beautiful Dreamer" by Foster), or familiar classical music were discarded. In addition, excerpts using vocals were discarded to avoid the possibility of words or syllables providing memory cues. The goal in choosing the final stimulus set was to choose excerpts that would be recognizable but would not have so many cues as to make them easily distinguishable from other excerpts. The excerpts used in the current study were chosen from those remaining based on their valence. Valence ratings were computed on a continuous scale from *negative* (low) to *positive* (high), using a scale of 1–7 (Eerola and Vuoskoski (2011). Mean ratings for valence of the final selected excerpts taken from the Eerola and Vuoskoski (2011) set were 5.32 ($SD = 1.14$) and 1.89 ($SD = .71$) for the pleasant and unpleasant, respectively.

The selected excerpts for the current study were presented to 93 pilot participants in a sample ranging in age from 18 to 81 years ($M = 26.4$, $SD = 13.9$). The pilot participants were asked to listen to the excerpts and to write "P" if they liked the items and

Table 2
Measures of Affect

Measure	*M*	*SD*	*F*	*p*	η_p^2
CES-D					
Young	11.69	6.06			
Middle-aged	10.87	8.05			
Old	9.03	7.21	1.644	$>.05$	.025
PANAS					
Positive					
Young	32.43	6.77			
Middle-aged	34.00	6.95			
Old	35.95	6.18	3.27	.04	.048
Negative					
Young	12.74	3.23			
Middle-aged	13.3	5.14			
Old	11.41	3.07	2.16	$>.05$	.06
FTP					
Young	57.61	7.28			
Middle-aged	54.9	8.87			
Old	39.78	12.14	46.18	$<.001$	.43

Note. CES-D = Center for Epidemiologic Studies Depression Scale; PANAS = Positive and Negative Affect Schedule; FTP = Future Time Perspective Scale.

Table 3
Cognitive Measures

	Young	Middle-aged	Old
St. Louis Mental Status Exam: $M = 27.4$ (1.4) (Participants aged 65 and up)			
Verbal paired associates			
Time 1	7.2 (3.5)	6.4 (3.2)	4.9 (2.0)
Time 2	11.2 (3.0)	10.1 (3.3)	7.0 (3.2)
Time 3	10.9 (3.3)	9.7 (3.4)	6.9 (3.4)
Digit span			
Forward	10.9 (2.4)	10.6 (2.3)	9.9 (2.1)
Backward	6.6 (2.6)	7.4 (2.2)	6.3 (2.2)
Total	17.2 (4.1)	18.0 (4.2)	16.2 (3.9)

perceived the item to be pleasant or to write "U" if they disliked the item and perceived it to be unpleasant. Musical preference was the basis for the ratings in the current study. Juslin and Sloboda (2011) defined musical preference as follows, "This term is used to refer to longer-term affective evaluations of objects or persons with a low intensity (e.g., liking of a particular type of music)" (p. 10). Results based on the pilot data ratings indicated excerpts selected to represent positive valence were rated and recognized as "pleasant" 60–100% across pilot study participants while excerpts selected to represent negative valence were rated and recognized as "unpleasant" 44–100% across pilot study participants.

Fourteen additional items from the Eerola and Vuoskoski (2011) stimulus set were used as "foils" and were specifically chosen for the current study to be comparable with the test excerpts. These musical excerpts were pilot tested with an additional set of 61 participants ranging in age from 18 to 75 years ($M = 25.25$, $SD = 10.23$). Participants were asked to listen to each excerpt and to write "P" if they liked the excerpt and perceived it to be pleasant or to write "U" if they disliked the excerpt and perceived it to be unpleasant. For this set of "foil" excerpts, items selected to represent positive valence were rated as "pleasant" by 67–100% of the participants while excerpts selected to represent negative valence were rated as "unpleasant" by 67–100% of the participants. (See Appendix for a list of stimuli and foils used in the current study).

Participants in the current study heard the 14 musical excerpts twice and were asked to study, rate the items and study for further testing, or to simply rate the items based on their pleasantness and unpleasantness (whether they perceived the excerpt to be pleasant or unpleasant). The musical excerpts and the "foil" excerpts were then randomly presented to the participants during the recognition memory test. The timing and presentation of the 14 musical excerpts and the 14 foils were programmed using E-Prime 2.0 (Schneider, Eschman, & Succolotto, 2002) and presented on a Dell Inspiron 1018, using an Intel ® Atom ™ CPU N455 @ 1.66 GHz, 32-bit Operating System. Each excerpt was programmed to play for exactly 10 s, and the excerpts were presented in random order each time for each participant. All possible orders of items were randomized across participants because of the study's mixed design (both within and between subject variables) and large number of participants (Field, 2009; Keppel & Wickens, 2004). Specifically, the Eprime software was set to randomly select and present all excerpts, then exit the list after one cycle, indicating that for each time the program was run, the excerpts during the two presentations, and subsequent targets and foils during the testing session, were randomly presented for each participant, avoiding potential order effects that could occur with counterbalancing.

Conditions. Three experimental conditions were presented in the current study with random assignment to condition within each age group: study only—Participants listened to the musical excerpts and were instructed to learn them for later recognition; rate only and rate and study—Participants listened to the musical excerpts and rated them as "pleasant" or "unpleasant" by pressing the "p" or "u" keys. Between each excerpt, the instructions were displayed on the computer monitor about how to respond on the computer keyboard: "Press 'u' if you find the music unpleasant" and "Press 'p' if you find the music pleasant." Participants had 5 s to make a decision about the pleasantness or unpleasantness of the excerpt before the next excerpt began. A surprise recognition test was administered at the end of the session for the *rate only* condition. Participants in the *study* and *rate and study* conditions were told that their memory for the music would be tested at the end of the study.

Procedure

Individual testing sessions were conducted and took ~1 hr. The administration sequence of the measures is shown in Figure 1. Following a demographic information interview, the SLUMS (Tariq et al., 2006) was administered to participants over 65 years of age. All participants were screened for hearing and were then given the first presentation of the VPAT (Uttl et al., 2002). No participants were excluded from the sample based on the SLUMS or hearing test results.

The first encoding presentation of the musical stimuli followed the VPAT. Participants then completed the PANAS (Watson et al., 1988), the second presentation of the VPAT, followed by the Forward and Backward Digit Span Subtests (Wechsler, 1981). After answering questions about their previous music experience, the musical excerpts were again played in random order for the participants to enhance encoding, followed by the last VPAT administration.

Participants heard the musical excerpts through over-the-ear noise cancelling headphones, Phillips, model SHP2500, 15–22,000 Hz frequency range, 100 dB sensitivity, 32 Ohm impedance, 500 mW maximum power output. The researcher concurrently heard the musical excerpts via a "Y" connector to monitor stimulus presentation. Finally, the recognition memory test for the musical excerpts was administered. Participants heard the 14 musical excerpts with 14 "foil" excerpts interspersed in random order and were asked to indicate whether each item was old (recognized) or new. The response instructions were displayed on the computer screen between each musical excerpt and also on a laminated card placed beside the computer keyboard. Participants pressed the "r" key on the computer keyboard if they recognized (remembered) the excerpt and recalled something they had thought or felt when hearing the excerpt earlier. The "k" key was pressed if they

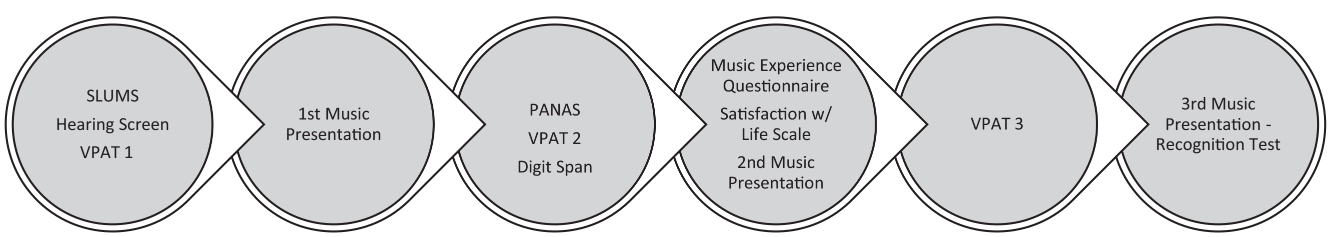

Figure 1. Administration sequence of measures.

recognized (knew) the excerpt from an earlier presentation, but did not recall anything they thought or felt when hearing it earlier. The “g” key was pressed if they thought they might have heard the excerpt earlier in the testing session. The “n” key was pressed if the excerpt was new (they had not heard it earlier in the testing session). Participants had an unlimited amount of time to make the decision about whether or not they recognized the musical excerpt.

Results

The current study was designed to examine age group differences between young, middle-aged, and older adults on auditory recognition memory for emotionally valenced musical excerpts. The relations between the pleasantness/unpleasantness of the musical excerpts based on positive and negative valence as well as auditory recognition (source) memory for the excerpts were examined and are presented below following a summary of results based on preliminary analyses.

Preliminary Analyses

To control for the possible confound of recognizing the musical scores derived from the listed movies (see Appendix) participants were asked to indicate the number of movies they had seen from which the excerpts of music were taken. An ANOVA was conducted using number of movies seen as the dependent variable and age group as the independent variable. A significant difference in the total number of movies seen was noted across age groups, $F(2, 132) = 7.46$, $p = .001$, $\eta_p^2 = .10$, occurring between the young ($M = 3.02$, 95% CI [2.04, 3.63]) and the middle-aged groups ($M = 4.83$, 95% CI [3.76, 5.89]), $p = .002$, and between the middle-aged group and the older group ($M = 2.98$, 95% CI [2.41, 3.54]), $p = .003$. While middle-aged adults saw significantly more of the movies from which the excerpts were chosen, this had no significant effect on recognition accuracy for the musical excerpts. This finding would be expected, as the excerpts came from movies from the time period between 1976 and 2006. During this time period, participants who were middle-aged during the time of the study would have been in the age group most likely to attend movies (mpaa.org, 2012). Eerola and Vuoskoski (2011) limited selection to soundtracks from this time period in order to maintain a consistent sound quality across the validated set of stimuli. Results of an ANOVA using valence ratings as the dependent variable and the movies seen were not significant, $p = .16$, indicating that having seen the movie the excerpt was from did not have an effect on the valence ratings. An ANCOVA was conducted to determine the effect of movies seen or not seen and on total correct scores. Neither of the covariates was significant, valence ratings: $F(1, 64) = .01$, $p = .920$, $\eta_p^2 = .00$, and movies seen or not seen: $F(1, 64) = 2.47$, $p = .121$, $\eta_p^2 = .007$, indicating that recognition performance was not affected by the participants’ pleasant or unpleasant valence ratings or by whether or not the participants had seen the movie the excerpts were from.

Main Analyses

Three types of analyses were performed: valence of musical excerpts, validity check, mixed analysis of variance (mixed ANOVA) based on the proportion of total hits minus false alarms, and analyses of remember and know responses.

Valence of musical excerpts: Validity check. The reliability of subjective ratings for pleasant and unpleasant musical excerpts was conducted to ensure that participants perceived the emotional valence of the excerpts in the manner intended. Ratings of the musical excerpts in the rate only condition and the rate and study condition were highly reliable, with Cronbach’s alpha ranging from .74 to .92 across both conditions and age (.52 to .95) with the exception of the middle-aged group in the rate only condition for the pleasantness ratings ($\alpha = .32$).

Proportion of Total Hits—False Alarms Analyses. A mixed ANOVA was conducted with the Proportion of Total Hits—False Alarms, or corrected recognition memory score, as the dependent variable. The hit rate consisted of true recognition memory responses as well as guesses. The proportion of Total Hits—False Alarms was used as the dependent variable to correct for guessing (Snodgrass & Corwin, 1988). The between-subjects variables were age (young, middle-aged, old) and condition (study only, rate only, rate and study). The within-subjects variable was valence (pleasant, unpleasant). Effect sizes are reported as generalized eta squared according to Bakeman (2005). A large main effect of age, $F(1, 126) = 43.4$, $p < .001$, $\eta_G^2 = .34$, and a small main effect of valence was noted, $F(1, 126) = 49.34$, $p < .001$, $\eta_G^2 = .11$, as well as a small Age $\times$ Valence effect, $F(2, 126) = 3.57$, $p = .031$, $\eta_G^2 = .01$ (see Figure 2). Neither the main effect nor interactions involving condition were significant and were excluded from further analyses, all ps $> .05$.

Simple repeated ANOVAs with Bonferroni correction were performed for each age group (young, middle-aged, old) to further examine the Age $\times$ Valence effect. The dependent variable for this computation was proportion of total hits—false alarms (corrected recognition memory score). The within-subjects variable was valence (pleasant, unpleasant). A main effect of valence was noted within each age group: young, $F(1, 53) = 6.53$, $p = .013$, $\eta_G^2 = .03$; middle-aged, $F(1, 39) = 29.16$, $p < .001$, $\eta_G^2 = .13$; and old, $F(1, 40) = 15.51$, $p < .001$, $\eta_G^2 = .098$, in which all participants in each age group recognized more pleasant than unpleasant excerpts. Simple one-way ANOVAS were also performed separately for the Pleasant and Unpleasant trial types. The dependent variable was proportion of total hits—false alarms (corrected recognition memory score). The between-subject variable was age (young,

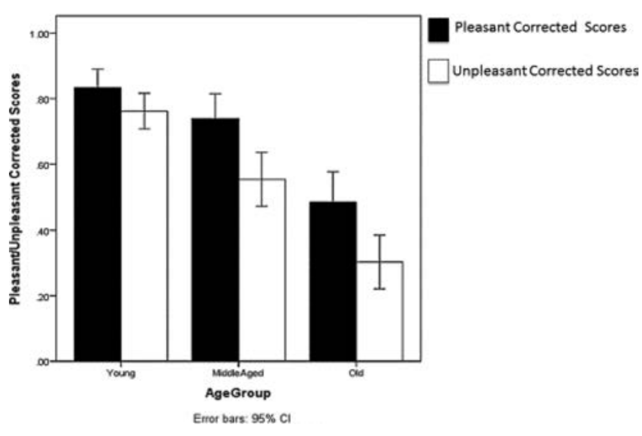

Figure 2. Corrected recognition scores for pleasant and unpleasant excerpts.

middle-aged, old). A main effect of age was noted for both pleasant, $F(2, 132) = 24.74$, $p < .001$, and unpleasant, $F(2, 132) = 43.99$, $p < .001$, excerpts when examined separately. Post hoc analyses using Bonferroni correction revealed that young adults ($M = .83$, $SD = .03$; pleasant corrected recognition memory score) recalled more pleasant excerpts than did older adults ($M = .48$, $SD = .29$), as did middle-aged adults ($M = .74$, $SD = .24$). Younger adults ($M = .76$, $SD = .2$) also performed significantly better on proportion of unpleasant hits—false alarms (unpleasant corrected recognition memory score) than either the middle-aged ($M = .55$, $SD = .26$) or older adults ($M = .3$, $SD = .26$), and middle-aged adults performed significantly better than older adults.

Analysis of positivity effect. A one-way ANOVA was conducted to determine the presence of the positivity effect, using a split file by age groups for comparison. The independent variable was valence (pleasant, unpleasant) and the dependent variable was recognition score. Results were not significant for the young ($p > .05$) but were for middle aged, $F(1, 78) = 10.38$, $p = .002$, as well as for older adults, $F(1, 80) = 8.79$, $p = .004$. Paired samples t tests for middle-aged and older adults were performed using Recognition memory scores and Valence as the paired variables. Results indicated that both middle-aged and older participants recognized significantly more pleasant excerpts than unpleasant excerpts ($M = .73$, $SD = .23$; $M = .55$, $SD = .26$, $t(78) = 3.22$, $p = .002$; $M = .49$, $SD = .29$; $M = .30$, $SD = .26$, $t(80) = 2.96$, $p = .004$, respectively). These results indicate the presence of the positivity effect for the middle-aged and older adults in the current sample.

Analyses of know and remember responses. Age-related differences in the number of correct know and remember responses and false alarms were examined by using mixed ANOVAs with Bonferroni correction for post hoc analyses. For know responses, the dependent variables were correct know responses and know false alarms. The between-subjects variable was age group (young, middle-aged, and old) and the within-subjects variable was valence (pleasant, unpleasant). Results indicated no main effect of age for know correct responses and false alarms, ps $> .05$. Because results of this analysis were nonsignificant, further analysis was not conducted for know responses. For remember responses, the dependent variables were proportion of correct remember responses and remember false alarms. The between-subjects variable was age group (young, middle-aged, and old) and the within-subjects variable was valence (pleasant, unpleasant). Results indicated a main effect of age for both remember hits—false alarms, $F(2, 131) = 23.99$, $p < .0001$, and for remember false alarms, $F(2, 132) = 9.97$, $p < .0001$. Young adults had significantly more correct remember responses ($M = .87$, $SD = .09$) than older adults ($M = .69$, $SD = .12$), and middle-aged adults ($M = .80$, $SD = .11$) had significantly more correct remember responses than older adults. Older adults had significantly more false alarm remember responses ($M = .30$, $SD = .10$) than young adults ($M = .13$, $SD = .09$). Middle-aged adults ($M = .20$, $SD = .11$) had significantly more false alarm remember responses than young adults, indicating that episodic memory was less accurate for older adults in this sample, supporting other findings indicating age-related differences in episodic memory (Bastin & Van der Linden, 2003; McCabe et al., 2009). A main effect of valence was noted for remember responses, $F(1, 126) = 16.78$, $p < .001$, $\eta^2 = .12$. Across all age groups, the mean proportion of pleasant remember hits—false alarms, $M = .6$ ($SD = .03$) was greater than the mean proportion of unpleasant remember hits—false alarms, $M = .5$ ($SD = .02$), indicating the participants correctly endorsed remember responses for more of the pleasant excerpts than the unpleasant excerpts. Paired samples t tests using data split by age group with proportion of consonant remember hits—false alarms and proportion of dissonant remember hits—false alarms as the paired variables were performed to examine age-related differences. There was no significant differences noted for young adults. Results indicated middle-aged adults correctly endorsed more remember responses for pleasant musical excerpts ($M = .66$, $SD = .30$) than for unpleasant musical excerpts ($M = .56$, $SD = .24$) $t(39) = 2.44$, $p = .019$, and older adults also correctly endorsed more remember responses for pleasant musical excerpts ($M = .41$, $SD = .31$) than for unpleasant musical excerpts ($M = .25$, $SD = .27$), $t(40) = 3.36$, $p = .002$.

Discussion

The current study examined differences in auditory recognition memory between young, middle-aged, and older adults using pleasant and unpleasant musical excerpts. In the following discussion, we revisit the three objectives of the study, summarize the results, and finally consider the implications of how emotion may be related to cognitive aging within an auditory processing domain such as music.

The first objective of the study was to examine if the positivity effect based on the socioemotional selectivity theory (Carstensen, 1992, 1995) would be evident in an auditory domain such as music. We expected that older adults would recognize more pleasant musical excerpts than unpleasant excerpts, while young adults would recognize more unpleasant than pleasant excerpts. The presence of the positivity effect in our sample of older adults in addition to their lower optimism about the future and perceived limitations on time as measured by the Future Time Perspective Scale (Carstensen & Lang, 1996), supports the hypothesis of the socioemotional selectivity theory (i.e., because of a change in goals, older adults' focus shifts from preferential processing of negatively valenced information to preferential processing of positively valenced information). Interestingly, the presence of the positivity effect was noticed in middle-aged adults in our sample as well as in older adults. This finding also provides support for a proposed age-related shift in preferential processing of negative information to that of processing positive information. Only a longitudinal study will allow the nature of this shift to be better understood. It is interesting that middle-aged adults in the rate and study condition rated the musical excerpts as being less pleasant overall than young and older adults in the same condition. However, they recognized significantly more of the pleasant excerpts than the unpleasant. There were no significant differences across age groups and conditions for CES-D and negative scores on the PANAS. Therefore, individual differences such as specific musical preference may account for the ratings of these middle-aged participants. In spite of their lower ratings, middle-aged adults in this condition recognized significantly more pleasant than unpleasant excerpts on the recognition memory test, suggesting that directing their attention to the emotional content did not enhance their auditory recognition memory.

The second goal of the current study was to explore differences in recognition memory for musical excerpts under varied instructions that differed in encoding demands. Blanchet et al., (2006) examined age-related differences in memory using conditions in which participants were told either to study tunes for later recognition, make a judgment regarding whether the tune was a march or a waltz with no mention of a later recognition test, or to make the march/waltz judgment while studying the tunes for a later recognition test and found that older adults had better recognition memory in the intentional memory condition. They suggested making an emotional judgment (i.e., whether musical excerpts are pleasant/liked or unpleasant/disliked) might facilitate encoding of musical excerpts, helping to reduce age-related differences in recognition memory. Contrary to what was expected, there were no significant differences in recognition memory for musical excerpts across instruction conditions in the current study. Younger adults recognized significantly more musical excerpts than older adults across all conditions. We suggest, therefore, that simply directing participant's attention to the emotional content of a stimulus may not significantly facilitate recognition memory in older adults. Older adults should have displayed enhanced recognition memory for musical excerpts in the rate and study condition if paying attention to emotional content facilitated recognition memory, but this advantage was not observed in the current sample.

There are notable differences in stimuli and presentation conditions between our study and the Blanchet et al., (2006) study. The stimuli for the current study were chosen from a set of excerpts from movie sound tracks (Eerola & Vuoskoski, 2011), and were presented in full orchestral voice, while the excerpts from the Blanchet et al. (2006) study were from the Montreal Battery of Evaluation of Amusia, used for evaluation of patients with brain damage (Ayotte, Peretz, & Hyde, 2002), and were presented in a piano voice using a MIDI sequencing program. It is possible that, because the stimuli in the Blanchet et al. (2006) study were presented in a single voice as opposed to the multiple orchestral voices as in our study, older participants in our study condition were not able to sufficiently isolate differences between stimuli and foils during recognition testing. This is not likely because there was no significant difference in older adults' recognition memory across conditions. If the older participants had not been able to isolate the differences, they would have performed quite poorly on the recognition memory test. While they did not perform as well as young and middle-aged adults, they were able to accurately recognize the excerpts above chance.

The third objective of the current study was to examine age-related differences in recognition memory for musical stimuli based on the dual process theory (i.e., familiarity and recollection). We expected that source memory for musical excerpts, as measured by remember and know responses to stimuli, would be less evident in older adults. Source memory for information declines with age and is evident when older adults endorse significantly more responses of "familiarity" (know responses) than "recognition" (remember responses; Bastin & Van der Linden, 2003; McCabe et al., 2009). There were no differences across age group in our sample for correct know responses and false alarms. However, older adults had fewer correct remember responses than younger and middle-aged adults and more false alarm remember responses than younger and middle-aged adults.

We are not the first to use the "remember/know" paradigm to examine memory for emotionally valenced information. Kensinger and Corkin (2003) examined remember and know responses for emotionally valenced and neutral words and reported that young adults endorsed a remember response more frequently for words with an emotional component than neutral words. Kapucu, Rotello, Ready, and Seidl (2008) observed that older adults also exhibited a remember response preference for words. Deason, Hussey et al. (2012) noted that healthy older adult participants in a study examining recognition memory for visually presented words likely relied on both recollection and familiarity to make judgments about whether words were old or new but that longer delays between presentation of the stimuli and testing would be expected to trigger more feelings of familiarity. Gardiner et al. (1996) used the remember/know procedure to examine college students' recognition memory for musical excerpts but did not examine age-related differences. Older adults frequently display an age-related decline in episodic, or source memory (Tulving & Markowitsch, 1998). We suggest that older adults in our sample were representative of the larger population because they had significantly more false alarm remember responses and fewer correct remember responses.

Limitations and Recommendations

It is possible that the forced choice responses of "pleasant" and "unpleasant" for rating the musical stimuli may not have accurately represented the participants' valence perception. Future studies examining music and the positivity effect may wish to consider use of a Likert rating scale ranging from positive to negative rather than a dichotomous rating to more accurately measure participants' perception of the valence of excerpts.

While the careful distinction between remember and know responses was emphasized in the recognition memory test instructions, it is possible that our participants did not fully understand the concepts involved. However, each participant indicated they understood the difference between the two categories when asked before testing. It is also likely that the short duration of the stimuli and of the study itself may have made it difficult for participants to differentiate between the remember and know responses. However, other studies examining age differences in episodic memory (Bastin & Van der Linden, 2003; McCabe et al., 2009) visually presented stimuli for 5 s or less and found similar results. Future studies examining auditory recognition could include longer excerpts as stimuli (e.g., an entire musical phrase) to more fully examine this response distinction.

Conclusion

The results of our study revealed age-related differences in auditory recognition (episodic) memory for pleasantly and unpleasantly valenced musical excerpts. Middle-aged and older adults correctly recognized significantly more pleasantly valenced excerpts than did young adults. These results provide further support for the positivity effect in adulthood and aging in the domain of auditory processing. Past studies using auditory stimuli supported the positivity effect in terms of reduced recognition of negative emotions expressed by music (Lima & Castro, 2011) and in ratings of perceptions of complexity in valence and arousal

(Vieillard et al., 2012). However, the current study provided evidence specifically for the positivity effect in auditory recognition (episodic) memory for musical excerpts.

Understanding the underlying nature of music processing could further expand our knowledge of the relation between cognition and emotion, especially in adulthood and aging. Specifically, in which domains and under what conditions is the positivity effect evident in adulthood and aging? Episodic memory is very age-sensitive and shows sharp declines with age (Brickman & Stern, 2009). Middle-aged and older adults in the current study demonstrated better episodic memory for pleasant musical excerpts than for unpleasant excerpts. According to Tulving (1985), episodic memory includes mentally traveling back in time to reexperience the event and is a uniquely human experience. We suggest that our finding of the positivity effect in the auditory domain combined with the finding of better episodic memory for pleasant musical excerpts on the part of middle-aged and older adults in our sample may be useful to consider in the development of interventions to improve episodic memory using auditory materials. Older adults may not initially encode episodic memories as deeply as younger adults (Brickman & Stern, 2009). However, based on the current study, it can be hypothesized that the use of pleasantly valenced music as memory cues may allow individuals to process the context of episodic memories more deeply, allowing them to recall important episodic memories more accurately.

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(*Appendix follows*)

Appendix

Stimuli Set

Number	Pleasant/Unpleasant	Album name
002	Pleasant	*The Rainmaker*
004[a]	Pleasant	*Man of Galilee*
005[a]	Pleasant	*Shakespeare in Love*
006[a]	Pleasant	*The Rainmaker*
007	Pleasant	*Man of Galilee*
009[a]	Pleasant	*Band of Brothers*
022[a]	Pleasant	*Shakespeare in Love*
025	Pleasant	*Big Fish*
066[a]	Pleasant	*The Missing*
105	Unpleasant	*Road to Perdition*
111[a]	Unpleasant	*Cape Fear*
133	Pleasant	*Cape Fear*
144[a]	Unpleasant	*Cape Fear*
146	Unpleasant	*The Missing*
154[a]	Unpleasant	*Naked Lunch*
163[a]	Unpleasant	*Naked Lunch*
164[a]	Unpleasant	*Naked Lunch*
182[a]	Pleasant	*Dances With Wolves*
191	Pleasant	*The Godfather*
198	Pleasant	*The Omen*
212[a]	Unpleasant	*Batman Returns*
214	Unpleasant	*Grizzly Man*
215	Unpleasant	*Grizzly Man*
217	Unpleasant	*Lethal Weapon 3*
232	Unpleasant	*Batman Returns*
237	Unpleasant	*The Fifth Element*
264	Pleasant	*Dances With Wolves*
266[a]	Unpleasant	*JFK*

[a] Denotes repeated stimuli.

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