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Music-Evoked Autobiographical Memories are Associated with Negative Affect in Younger and Older Adults

Kendra Mehl[a], Alaine E. Reschke-Hernandez[b,c], Julien Hanson[a], Lauren Linhardt[a], Jessica Frame[a], Matthew Dew[a], Elizabeth Kickbusch[a], Chase Johnson[a], Elena Bai[a], and Amy M. Belfi[a]

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ABSTRACT

BACKGROUND: Music evokes strong and persistent emotional responses. However, the mechanisms underlying the emotional effects of music, particularly in older adults, are largely unknown. One purported mechanism by which music evokes emotions is through memory – that is, music evokes personal, autobiographical memories that then lead to emotional responses.

METHOD: Here, we investigated whether memory-evoking music induces stronger and longer-lasting emotional responses than non-memory-evoking music, and whether these emotional responses differ between younger and older adults. Older (N = 30) and younger adults (N =30) listened to two blocks of self-selected music (one block of memory-evoking music and one block of familiar but non-memory-evoking music). Participants reported their emotions prior to and at three timepoints post-listening.

RESULTS: Older adults reported higher levels of positive affect than younger adults. For both groups, positive affect increased after listening to both memory-evoking and non-memory-evoking music. However, negative affect only increased after listening to memory-evoking music.

CONCLUSIONS: These results suggest that both memory-evoking and non-memory-evoking music generate strong emotions in younger and older adults, but music that conjures personal memories is more likely to elicit mixed emotions. Our results have important clinical implications when designing music-based interventions for mood and affect, particularly in older adult populations.

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Music can be a highly potent stimulus for evoking emotional responses. In fact, a primary motivation to listen to music is due to its emotional properties: One of the most commonly reported reasons for listening to music is simply because it is enjoyable (Sanflippo, Spiro, Molina-Solana, & Lamont, 2020). Music can also evoke strong visceral responses, such as "chills," which are physiological reactions that are often accompanied by pleasurable feelings (for review, refer to Harrison & Loui, 2014). Taken together, a large body of research indicates that most people like music, choose to listen to it, and find it

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a pleasurable experience. However, it is important to note that the enjoyment of music varies from person to person. Some individuals on the extreme low end have what has been termed "musical anhedonia" (a specific lack of pleasure in response to music), whereas individuals on the high end have been deemed musically "hyperhedonic" (Martinez-Molina, Mas-Herrero, Rodríguez-Fornells, Zatorre, & Marco-Pallarés, 2019; Mas-Herrero, Marco-Pallares, Lorenzo-Seva, Zatorre, & Rodriguez-Fornells, 2013). Therefore, an individual's ability to experience the pleasurable impact of music varies as a function of their musical reward sensitivity. Although there are individual differences in musical reward, music maintains at least some degree of emotional potency for all but a small subset of the population deemed musically anhedonic.

While prior work has highlighted that musical reward can vary across individuals, researchers have more recently begun investigating whether there are differences in musical reward across the lifespan. Our recent work indicated that older adults continue to experience strong emotions in response to music, particularly the visceral and physiological components of musical reward (Belfi, Moreno, Gugliano, & Neill, 2022). That is, in prior work, older adults did not show any difference in strong emotional responses to music when compared to younger adults. However, older adults did report reduced music-seeking behavior (i.e., they were less likely to look for new music and learn about new musical artists than younger adults). Other recent work has investigated sustained emotional responses to music listening in older adults. In one study, older adults with and without Alzheimer's disease listened to personally meaningful music that either evoked feelings of happiness or sadness, and they rated their feelings before listening and at regular intervals up to 20 minutes after listening. Results indicated that music-evoked emotions were persistent across both participant groups above baseline levels for up to 20 minutes post-listening (Reschke-Hernández, Belfi, Guzmán-Vélez, & Tranel, 2020). Taken together, music-evoked emotions appear to be persistent across the lifespan and over time – that is, older adults display strong emotional responses to music that can last well after exposure.

However, it is unknown *how* music maintains its emotional impact or what mechanisms underlie the ability of music to induce strong emotions across the lifespan and over time. While our prior work found that music-evoked emotions can occur regardless of age and can be maintained after listening, it is unclear what it is about music that enables it to evoke such strong and persistent emotions. One prominent theory, which outlines several potential mechanisms underlying music-evoked emotions, poses that memories are one such possible mechanism (Juslin, 2013; Juslin, Harmat, & Eerola, 2014). The BRECVEMA model includes eight purported mechanisms by which music can induce emotions (Brain stem reflex, Rhythmic entrainment, Evaluative conditioning, Contagion, Visual imagery, Episodic memory, Musical expectancy, and Aesthetic judgment). The *episodic memory* mechanism refers to the phenomenon whereby a musical selection evokes memories of an event in a listener's life, which subsequently leads to an emotional response. Thus, one way that music may trigger strong emotions is via the personally meaningful events in a listener's life (i.e., autobiographical memories) that it evokes, and that it is the memories themselves that trigger the emotional response.

Such music-evoked autobiographical memories have been a rapidly growing research focus in recent years. Music evokes memories that differ from memories evoked by other memory cues – for example, music-evoked autobiographical memories are more episodically detailed than those evoked by pictures of famous persons (Belfi, Bai, Stroud, Twohy, &

Beadle, 2022; Belfi, Karlan, & Tranel, 2016), contain more motor-perceptual details than memories evoked by event cues (Zator & Katz, 2017), are associated with greater episodic reexperiencing than memories evoked by television shows (Jakubowski, Belfi, & Eerola, 2021), and are considered more personally important than those evoked by food cues (Jakubowski et al., 2023). Music can also evoke memories in individuals with probable Alzheimer's disease, and often appears to be a more effective cue with this population than other stimuli (Baird, Brancatisano, Gelding, & Thompson, 2018; El Haj, Postal, & Allain, 2012).

Taken together, previous work has indicated that: 1) music can evoke strong emotional responses that appear to be sustained across the lifespan and over time, and 2) music can evoke vivid, detailed, and personally significant autobiographical memories. However, minimal research has examined the role of music-evoked memories as a *mechanism* underlying music-evoked emotions. That is, while music can induce strong emotions and vivid memories, little has been done to test whether music-evoked memories are a source of music-evoked emotions. Some work has suggested that music-evoked autobiographical memories tend to be retrieved in an involuntary manner, such that they are triggered spontaneously and with little cognitive effort (El Haj, Fasotti, & Allain, 2012). Other research has indicated that such involuntary autobiographical memories are associated with stronger emotional responses than voluntarily retrieved memories (Berntsen & Hall, 2004; Rasmussen, Johannessen, & Berntsen, 2014). Therefore, autobiographical memories could be a contributing factor in previously reported sustained emotional responses to music.

The overarching goal of the present study was to test the role of autobiographical memory as a mechanism for music-induced emotions. Here, we sought to investigate whether music that evokes autobiographical memories has a stronger emotional impact than music that does not evoke autobiographical memories. Furthermore, we tested whether the role of autobiographical memory in music-evoked emotions differs between younger and older adults. While our recent work suggests that older adults exhibit differences in their musical behaviors (i.e., lower music-seeking) than younger adults (Belfi et al., 2022), there is also a large body of research indicating that there are age-related changes in emotional processes more broadly. For example, the Socioemotional Selectivity Theory proposes that as people age and their time horizon shrinks, they focus more on their present emotions. Subsequently, older adults become more selective in their social experiences to maximize their emotional satisfaction (Carstensen, Isaacowitz, & Charles, 1999). Others have suggested that older adults have enhanced emotional regulation capabilities relative to younger adults, which may facilitate improved well-being in old age (Urry & Gross, 2010).

In addition to age-related changes in emotional functioning more broadly, related work has found an "age-related positivity effect" for memory. For example, older adults tend to remember more positive information, while younger adults remember more negative information, and older adults are less able to recall negative life experiences than younger adults (Charles, Mather, & Carstensen, 2003; Fernandes, Ross, Wiegand, & Schryer, 2008; Reed, Chan, & Mikels, 2014). Older adults also recall autobiographical memories that contain a greater proportion of semantic, rather than episodic details (Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002). Consistent with this phenomenon, older adults report lower autonoetic consciousness – a subjective sense of reexperiencing an event – during autobiographical memory retrieval (Piolino et al., 2006). Given the abundance of prior evidence that indicates age-related changes in memory and affect, the present work sought to investigate the role of music-evoked autobiographical memories as a mechanism underlying the ability of music to evoke emotions, and whether this mechanism differed between younger and older adults.

In the present study, participants (younger and older adults) listened to self-selected music that was either associated with or not associated with autobiographical memories. During the experiment, participants listened to their musical selections in a blocked manner (either memory-evoking first or non-memory evoking first). They rated their emotions prior to listening and at regular intervals up to 20 minutes post-listening. Given the previously reported age-related positivity effect, we predicted that older adults would report more positive memories and more positive affect than younger adults. Additionally, we predicted that memory-evoking music would have a stronger emotional impact than non-memory-evoking music and that this emotional impact would also be longer lasting. Finally, we predicted that memory-evoking music would be associated with mixed emotions (i.e., a mix of positive and negative emotions) moreso than non-memory-evoking music, which we predicted would be associated with primarily positive emotions.

Methods

Participants

Participants consisted of 30 younger adults (Male = 15, Female = 15; age range: 18–35, *M* = 19.9 years, *SD* = 1.3) and 30 older adults. One older adult participant was excluded for a high score on the Mini-Mental State Exam, indicating severe cognitive decline, leaving a total of 29 older adults (Male = 12, Female = 17; age range: 65–84, *M* = 72.2 years, *SD* = 6.3). We calculated our target number of participants using data from our prior work in a similar experiment (Reschke-Hernándezet al., 2020), which examined emotional responses to music in older adults and reported an effect size of $\eta^2_p = 0.09$ (a moderate-to-large effect size, Cohen, 1988). Using this value in our power analysis conducted with G*Power software (for repeated measures, within-between interaction, with two groups and four measurements at an alpha level of 0.05) indicated that a sample of 24 would be sufficient to detect a similar effect (Faul, Erdfelder, Lang, & Buchner, 2007). To account for possible attrition, we sought to recruit 30 per group. Participants were recruited through the Missouri University of Science and Technology campus and from the local and regional community areas through flyers and community outreach. All participants had normal or corrected-to-normal vision and hearing and no history of severe neurological or psychiatric conditions.

Participants were well-characterized on a series of perceptual and cognitive tests. Due to the age of our participants, many likely had some degree of hearing loss. Rather than exclude individuals on the basis of hearing loss or use of hearing aids, we administered a pure-tone audiometric screening for descriptive purposes (similar to Reschke-Hernández etal., 2020). Participants completed the screening in a quiet room using a portable iPad-based Shoebox Audiometer (SHOEBOX; Clearwater Clinical, Ottawa, Ontario, Canada) using calibrated noise-canceling headphones that generated a series of tones at four frequency levels (500, 1000, 2000, and 4000 Hz) at different decibel (dB) levels.

They were instructed to signal by raising their hand when they heard a tone. We then calculated a pure-tone average dB hearing threshold at 500, 1000, 2000, and 4000 Hz in each ear. One older adult participant chose not to complete the audiometric screening and self-reported that they did not have any hearing loss.

Next, participants completed a brief battery of cognitive tests, which we primarily used for descriptive purposes and to exclude any participants with severe cognitive decline or depression. Because depression influences the intensity and duration of the experience of emotions and could complicate interpretation of the primary outcome of interest in our experiment (i.e., emotions), participants completed the Beck Depression Inventory (Beck, Steer, & Carbin, 1988). As an index of processing speed, fluidity, and working memory, participants completed the Trail Making Test (Bowie & Harvey, 2006). As a screening for cognitive impairment and brief measure of overall cognitive status, participants completed the Mini-Mental State Exam (MMSE; Folstein, Folstein, & McHugh, 1975). One older adult participant was excluded from the study for a low MMSE score, but otherwise no participants met the cutoff score for any other test. Participants completed the Barcelona Musical Reward Questionnaire (Mas-Herrero, Marco-Pallares, Lorenzo-Seva, Zatorre, & Rodriguez-Fornells, 2013) to measure musical reward and provided total years of formal musical training as a measure of musical experience. Finally, general intelligence was measured using the Wechsler Test of Adult Reading (WTAR; Wechsler, 2001). Results of these measures are summarized in Table 1.

To assess whether the groups differed on these descriptive variables, we conducted a series of independent samples t-tests. Older adults had significantly more years of education than younger adults ($t(57) = 3.37$, $p = .001$, $d = 0.88$), as our younger adult participants were primarily current college students. Older adults had significantly more hearing loss (right ear: $t(56) = 9.37$, $p < .001$, $d = 2.53$; left ear: $t(56) = 7.88$, $p < .001$, $d = 2.17$) and performed significantly slower on the Trail Making Test (Part A: $t(57) = 5.78$, $p < .001$, $d = 1.54$; Part B: $t(57) = 3.08$, $p = .003$, $d =$

Table 1. Demographic information.

	Older Adults	Younger Adults
Age (years)	72.2 (6.3)	19.9 (1.3)
Education (years)	16.6 (4.3)	13.7 (1.2)
Sex	17 F, 12 M	15 F, 15 M
Handedness	26 RH, 3 LH	28 RH, 2 LH
Beck Depression Inventory[1]	5.0 (3.8)	4.7 (5.6)
WTAR raw score[2]	43.4 (6.5)	40.3 (4.6)
Trail Making Test (seconds)		
A	30 (12.6)	15.6 (3.8)
B	67.3 (26.4)	45.9 (27.0)
Mini-Mental State Exam	29 (1.1)	29.6 (0.8)
BMRQ	76.4 (10.8)	78.4 (11.0)
Musical Training (years)	2.1 (3.3)	2.9 (3.3)
Pure-Tone Average (dB)[3]		
Right Ear	26.4 (10.1)	7.2 (3.9)
Left Ear	27.0 (11.0)	8.9 (4.4)

All values are mean (SD) except where noted. 1. Scores range from 0 to 14 (minimal), 14 to 20 (mild), 20 to 29 (moderate), and > 29 (severe). No participants had severe BDI scores. 2. WTAR raw scores are out of a maximum of 50. 3. Obtained by averaging hearing threshold (in decibels, dB) at 500, 1000, 2000, and 4000 Hz; higher dB indicates greater sound intensity; 20–40 dB pure-tone average indicates mild hearing loss (Carhart & Jerger, 1959).

0.80). There were no significant differences between groups in depression scores ($t(57) = 0.21$, $p = .83$, $d = 0.05$), musical reward ($t(57)=-0.67$, $p = .50$, $d=-0.17$), or years of musical training ($t(57)=-0.90$, $p = .36$, $d=-0.23$). Older adults scored slightly lower on the MMSE ($t(57)=-2.20$, $p = .03$, $d=-0.57$) and slightly higher on the Wechsler Test of Adult Reading ($t(57) = 2.23$, $p = .03$, $d = 0.59$), although these results would not survive corrections for multiple comparisons given the nine statistical tests run on these demographic data.

Stimuli

As in our prior work, participants selected their own stimuli for use in the experiment (Reschke-Hernández et al., 2020). We chose to use self-selected (i.e., music selected by the participant) rather than experimenter-selected stimuli, as prior research indicates that personally meaningful music is the most emotionally evocative (Blood & Zatorre, 2001; Hargreaves & North, 2010; Koelsch, 2010; Pereira et al., 2011). Prior to participating in the experiment, each participant compiled two lists of music. For *memory-evoking music*, participants were asked to provide five selections that they associate with personal memories. To not bias participants toward choosing musical selections that evoke particular emotions, participants were given no instructions about the emotional content of the memories or emotional salience of the music. They were instead instructed to choose five musical selections that they most strongly associate with autobiographical memories, regardless of the emotional content of those memories or of the music itself. In addition to providing the list of stimuli, participants also briefly described each memory associated with each selection.

For *non-memory-evoking music*, participants were asked to provide five musical selections that they were familiar with and listened to with a similar frequency as the memory-evoking selections but that were *not* associated with autobiographical memories. Again, participants were given no instructions regarding the emotional content or evocativeness of the music. For both lists, participants provided the experimenters with the title and artist (and/or composer) of each musical selection. Participants could also indicate a particular segment of a selection if they wished (e.g., beginning, middle, or end; particular lyrics; number of minutes into the selection; etc.). The musical selections were provided ahead of time to the experimenters using a Qualtrics survey. Participants were given up to three weeks to determine their selections. A list of all musical selections made by participants can be found in the following OSF repository: https://osf.io/hpbmj

We created two separate playlists: one of memory-evoking music and one of non-memory-evoking music. For each musical selection, researchers identified one 50-second clip for the music listening portion of the experiment. If the participant did not specify a specific section, the experimenters selected the chorus or another highly recognizable part. Each musical clip included a 3-second fade in and a 3-second fade out, and we equalized volume across all clips within a set. A brief chime played between each musical clip. Thus, the total duration of each playlist (one for memory-evoking music and one for non-memory-evoking music) was approximately 4.5 minutes. This duration and playlist creation process was based on our prior work (Reschke-Hernández et al., 2020) as well as previous music-emotion induction research (Blood & Zatorre, 2001; Fairclough, van der Zwaag, Spiridon, & Westerink, 2014; Hilz et al., 2014).

Emotion Measures

Here, we used the same emotion measures as in prior work (Guzmán-Vélez, Feinstein, & Tranel, 2014; Reschke-Hernández et al., 2020). Participants self-reported their current emotional state throughout the experiment. The emotion measure was divided into three sections (the exact measure used is published in Guzmán-Vélez, Feinstein, & Tranel, 2014). The first section consisted of two 100-point visual analog scales (VAS), one each for happiness and sadness. On these VAS scales, participants were asked "How happy/sad do you feel right now?" and the anchors consisted of "I don't feel sad/happy at all" (0) and "I feel extremely sad/happy" (100). The second section consisted of two 9-point scales for valence and arousal. Participants were asked "How pleasant or unpleasant do you feel right now?" (valence) and "How intense or arousing are the emotions you feel right now?" (arousal). Anchors on the valence scale consisted of "extremely unpleasant" (0) to "extremely pleasant" (8) and anchors on the arousal scale consisted of "not at all intense" (0) to "extremely intense" (8). The third section of the emotion measure consisted of select emotion terms from the Differential Emotions Scale (DES; Izard, Dougherty, Bloxom, & Kotsch, 1974). Participants rated how much they were feeling each emotion (happy, sad, fearful, angry, touched, disgusted, anxious, calm) on a 9-point scale ranging from "not at all/ none" (0) to "extremely/a great deal" (8).

Procedure

All procedures were approved by the Institutional Review Board at the University of Missouri (IRB #2091530 ST) and informed consent was obtained from all participants prior to the experiment. Procedures followed closely from our prior work (Reschke-Hernández et al., 2020). The experiment consisted of two blocks: a) non-memory-evoking music and b) memory-evoking music. Musical block order was counterbalanced across participants to control for potential order effects. We followed the same procedures for both blocks (refer to Figure 1 for an illustration of the experimental procedure).

First, participants rated their baseline feelings using emotion measures described above (T0). Participants then set their preferred volume while listening to a 30-second music clip unrelated to the experiment. All music was played over external speakers connected to a computer monitor to offer more participant comfort and sensitivity to volume changes than headphones (Burack, Jefferson, & Libow, 2003). Personal volume adjustment was important to ensure all participants could hear the stimuli at their preferred comfort level and account for varied hearing acuity across participant groups. Participants then listened to their first musical playlist (either memory-evoking or non-memory-evoking) and

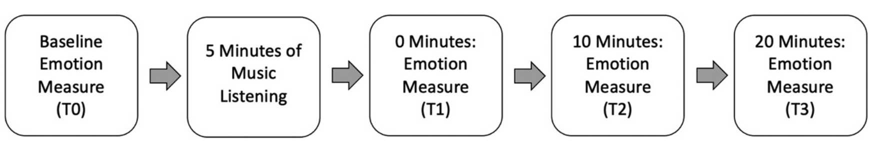

Figure 1. Timeline depicting the within-subjects procedure for administering emotion measures and music listening. Order was counterbalanced so that half of the participants listened to memory-evoking music first and half heard non-memory evoking music first.

completed the emotion measures immediately after music listening (T1). Participants again rated their feelings approximately 10 minutes after (T2) and 20 minutes after music listening (T3). During all waiting periods, participants were verbally prompted to sit quietly. After the final emotion measure, the entire procedure was repeated for the participant's second musical set. For a visual depiction of the procedure, refer to Figure 1.

Analysis

Emotion Ratings

As in our prior work (Reschke-Hernández et al., 2020), we looked at two measures of positive and negative affect. First, we looked at VAS ratings of happiness and sadness. Second, we looked at composite scores of overall negative and positive affect. To create composite scores, we first converted all valence and DES emotion ratings (0 to 8 scales) into standardized units of 0% to 100%, representing the "percent of maximum possible" (POMP; Cohen, Cohen, Aiken, & West, 1999), before starting the statistical analysis. This conversion maintained the integrity of the psychometric properties of the measure and allowed us to analyze all ratings on the same scale as the VAS ratings (which were scaled from 0 to 100 and thus already in POMP units). To calculate the negative affect composite score, we averaged POMP scores for the following variables: sadness VAS; valence (reverse scored); and sadness, anger, disgust, fear, and anxiety from the DES. For the positive affect composite score, we averaged POMP scores for the following variables: happiness VAS; valence; and happiness, touched, and calm DES. Finally, we looked at arousal separately and we converted arousal ratings to POMP units.

All statistical analyses were conducted using *R* version 4.2.3. To assess changes in emotion over time and differences between groups, we conducted linear mixed-effects models for each emotion measure (happiness VAS, sadness VAS, negative composite score, positive composite score, and arousal POMP). We used the *lmer* function from the *lme4* package in *R* (Bates, Maechler, Bolker, & Walker, 2015). These models included fixed effects of group, time, and their interaction, as well as random intercepts for participants. Contrasts were set as follows for group (Older Adults: 0.5, Young Adults: −0.5) and music type (memory-evoking: 0.5, non-memory-evoking: −0.5). Treatment contrasts were used for timepoint, with T0 set as baseline (T0: 0) and each additional time point set as 1.

Musical Selections

Given that this experiment used self-selected music, we sought to investigate whether the musical selections provided by the participants differed between musical conditions (memory-evoking and non-memory-evoking) or between groups. First, to examine lyrical versus non-lyrical selections between groups and conditions, we calculated the number of musical selections that contained lyrics or not. We then conducted chi-square tests to compare differences between groups (younger, older) and conditions (memory-evoking, non-memory-evoking). Second, for each song we calculated the "song-specific age" (i.e., the difference between the year of release minus the year of the participant's birth; Kopiez, Weigang, Platz, & Düvel, 2021). The song-specific age is a measure of how old a participant was when a song was released; if a participant was born in 1980 and chose a song from 1990 as one of their stimuli, the song-specific age for that song would be 10. Although not all musical selections in the present study were "songs," we chose to maintain the verbiage "song-specific age" to align with prior research on the topic. To assess differences between music type and groups, we conducted a 2 × 2 mixed ANOVA, with song-specific age as the dependent variable, group as a between-subjects variable, and music type as a within-subjects variable.

Memory Content

To investigate the types of memories associated with music and whether these differed between younger and older adults, we coded the participants' memories that they provided with their stimulus selections. First, memories were coded on *affect* as positive, negative, neutral, or mixed affect. Second, memories were coded on three levels of *specificity* based on prior research (Ford, Addis, & Giovanello, 2011): lifetime period (e.g., abstract knowledge about a time period, but no specific events), general event knowledge (e.g., memory for events that extend beyond a single day), and event-specific knowledge (e.g., memories that pertain to a single instance of a specific event). Each memory was coded by two raters; for any memories on which the raters did not agree (<20% of the time), a third rater made the final judgment.

Results

Emotion Ratings

First, we assessed changes in the visual analog scale (VAS) ratings of happiness and sadness over time. For happiness, the model revealed a main effect of time, such that participants rated their happiness above baseline (M = 57.2, SD = 24.4) at T1 (M = 68.4, SD = 18.8; β = 11.11, SE = 2.07, t = 8.55, $p < .001$) and below baseline at T3 (M = 53.2, SD = 28.2; β =-4.18, SE = 2.07, t =-2.01, p = .04). There was also a main effect of music type, such that non-memory-evoking music was rated overall as happier (M = 62.1, SD = 25.8) than memory-evoking music (M = 56.4, SD = 26.8; β =-5.84, SE = 2.94, t =-1.98, p = .04). There was also a significant main effect of group, such that older adults reported significantly more happiness overall (M = 65.9, SD = 25.1) than younger adults (M = 52.6, SD = 26.1; β = 14.20, SE = 5.81, t = 2.44, p = .01). Finally, there was a significant interaction between group and time, such that the younger adults showed a stronger hedonic impact (i.e., a more significant increase in happiness) between T0 and T1 (β =-13.05, SE = 4.15, t =-3.14, p = .001).

For sadness, the model revealed a main effect of time, such that there was greater sadness at T1 (M = 15.4, SD = 23.8) than T0 (M = 5.62, SD = 11.3; β = 9.54, SE = 1.49, t = 6.38, $p < .001$) and T2 (M = 9.43, SD = 18.0) than T0 (β = 3.61, SE = 1.49, t = 2.47, p = .01). However, this effect was driven by memory-evoking music:There was a significant interaction between music type and time, such that memory-evoking music – but *not* non-memory-evoking music – was associated with sadness levels above baseline at T1 (β = 14.88, SE = 2.99, t = 4.97, $p < .001$), T2 (β = 10.76, SE = 2.99, t = 3.59, $p < .001$), and T3 (β = 5.99, SE = 2.99, t = 2.00, p = .04). Refer to Figure 2 for a graphical depiction of these results. The full results of the two models as well as means and standard deviations for all groups and conditions can be found in the **Supplemental Materials**.

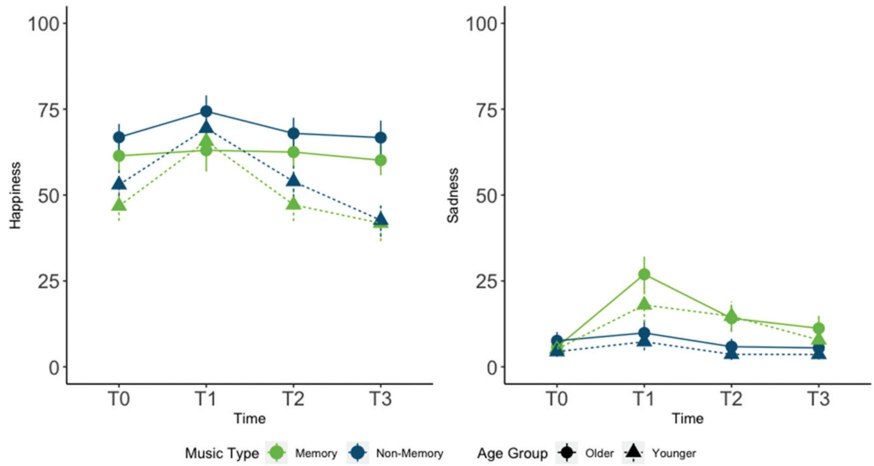

Figure 2. Emotion rating results for happiness and sadness. Error bars indicate standard error of the mean.

For positive affect, the model revealed a main effect of time, such that at T1 (M = 64.4, SD = 18.5; β = 12.40, SE = 1.45, t = 8.55, p < .001) and T2 (M = 55.3, SD = 19.8; β = 3.32, SE = 1.45, t = 2.29, p = .02) participants had significantly greater positive affect than at T0 (M = 51.7, SD = 18.8). There was also a significant main effect of group, such that older adults had significantly greater positive affect (M = 65.4, SD = 18.5) than younger adults (M = 46.5, SD = 17.1; β = 19.01, SE = 3.98, t = 3.98, p < .001). For negative affect, the model revealed a significant interaction between music type and time: memory-evoking music (but not non-memory-evoking music) was associated with significantly greater negative affect above baseline at T1 (β = 6.93, SE = 1.72, t = 4.02, p < .001) and T2 (β = 4.95, SE = 1.72, t = 2.87, p = .004). For arousal, the model revealed a significant main effect of time, such that at T1 (M = 49.0, SD = 26.4; β = 22.15, SE = 2.27, t = 9.73, p < .001) and T2 (M = 34.1, SD = 27.5; β = 7.16, SE = 2.27, t = 3.15, p = .001) participants had significantly greater arousal than at T0 (M = 26.6, SD = 25.9). Refer to Figure 3 for a graphical depiction of these results. The full results of the three models as well as means and standard deviations for all groups and conditions can be found in the **Supplemental Materials**.

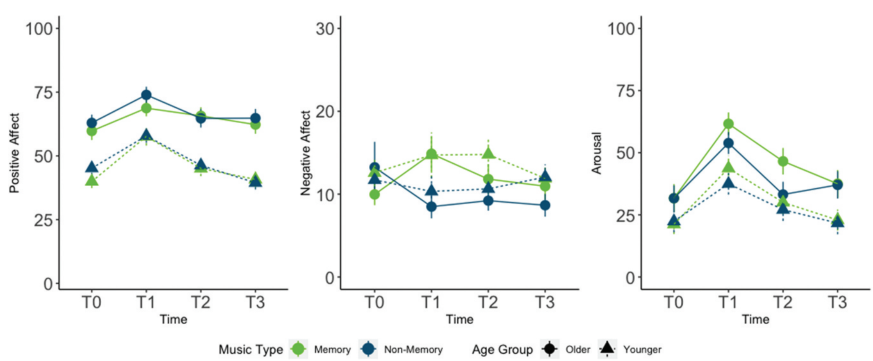

Figure 3. Emotion rating results for positive and negative affect composite scores, and arousal ratings. Error bars indicate standard error of the mean.

Musical Selections

We conducted two chi-square tests for differences in the proportion of lyrical and non-lyrical music. The first compared proportions between memory-evoking and non-memory-evoking selections, and the second was between older and younger adults. Both tests revealed no significant differences (both χ^2 <0.001, p>.99). Refer to **Table S7** in the **Supplementary Materials** for the distribution of lyrical and non-lyrical musical selections. We also conducted a 2 × 2 mixed ANOVA to assess the effects of age and music type on song-specific age (i.e., the age at which a participant was when the song was released), which revealed a main effect of group (F(1,112) = 9.19, p = .002, η^2 = 0.08) such that older adults chose musical selections with a higher song-specific age than younger adults. That is, the musical selections chosen by older adults tended to come from their adulthood, while the musical selections chosen by younger adults tended to come from their childhood or prior to their birth. The ANOVA also revealed a significant main effect of condition, such that memory-evoking music had a lower song-specific age than non-memory-evoking music (F (1,112) = 3.94, p = .04, η^2 = 0.03). That is, memory-evoking music tended to come from an earlier period of life than non-memory-evoking music (Figure 4).

Memory Content

We assessed the content of the memories reported for the memory-evoking music selections (non-memory-evoking music selections did not have any associated memories). We conducted a chi-square test to compare the proportion of affective codes (positive, negative, neutral, mixed) for the memory descriptions between groups, which revealed no significant effect (χ^2 = 0.04, p = .97). That is, both groups showed similar proportions of the quality of affective content of their self-reported memories. These memories were majority positive, with some neutral and mixed-emotional memories; negative memories were the least

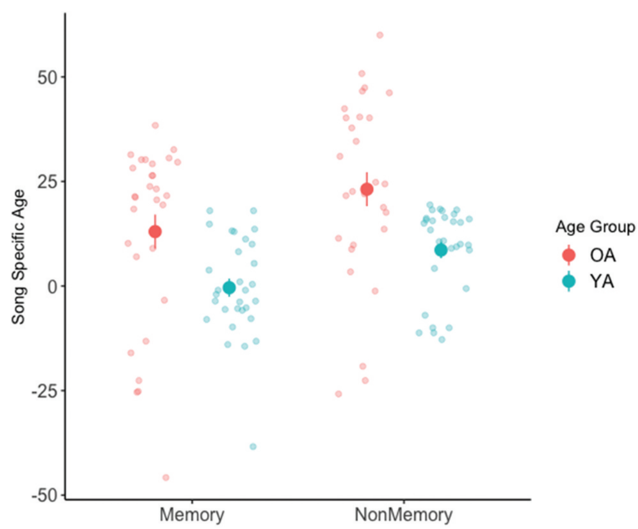

Figure 4. Song-specific age results. Large dots indicate mean; smaller dots indicate individual participants. Error bars indicate standard error of the mean. OA=Older adults, YA=Younger adults.

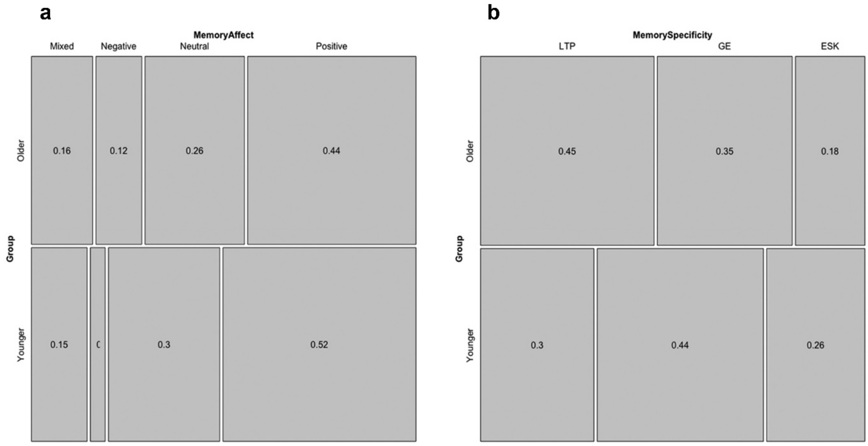

Figure 5. Proportion of memories for older and younger groups, based on A) affect ratings and B) specificity ratings. Bar heights illustrate the proportion of total memory reports by group. Bar widths illustrate the proportion of memories within each category. LTP=Lifetime period; GE=General event; ESK=Event-specific knowledge.

represented. Similarly, a chi-square test comparing specificity codes (lifetime period, general event, event-specific knowledge) between groups revealed no significant effect (χ^2 = 0.05, p = .97). The proportion of memories for each level of specificity was roughly balanced. Refer to Figure 5 for graphical depictions of these results.

Discussion

The primary goals of the present study were to identify whether memory-evoking music induced stronger or longer-lasting emotions than non-memory-evoking music and whether this phenomenon differed between younger and older adults. We predicted that memory-evoking music would induce stronger, longer lasting, and more mixed emotions than non-memory-evoking music. Overall, our results support these predictions to an extent – memory-evoking music was associated with stronger and longer-lasting emotions, but *only* for sadness and negative affect. We first looked at ratings of happiness and sadness and found that both increased after listening. However, in addition to these main effects of time, we found interactions between time, group, and music type. For happiness, we found a main effect of age: Overall, older adults reported more happiness across all conditions than younger adults. This finding supports the previously reported age-related positivity effect, such that older adults tend to attend to and remember more positive than negative information in contrast to younger adults (Carstensen & DeLiema, 2018; Carstensen et al., 2011). Interestingly, we saw an interaction between group and time, such that younger adults showed an increase in happiness after music listening and decreased happiness 20 minutes after listening. This finding also aligns with prior literature indicating that younger adults report negative affect more frequently than older adults (Reed, Chan, & Mikels, 2014). Younger adults' affective responses seemed to fluctuate more over time while older adults' remained more stable, perhaps reflecting age-related differences in emotion regulation (Urry & Gross, 2010).

For sadness, we found a main effect of time, but also a significant interaction between time and music type – that is, the increase in sadness after listening to music was driven by the effect of memory-evoking music. In both younger and older adults, listening to memory-evoking music was associated with increased sadness, which persisted until 20 minutes after listening, more so than when listening to non-memory-evoking music. Interestingly, we found that the sadness evoked by music listening endured longer than happiness (i.e., sadness was rated above baseline at T3). This is important to note when considering the design of music-based interventions – music does not always lead to a positive emotional response. However, sadness is not "bad" (in fact, many people enjoy music-induced sadness; for review, see Eerola, Vuoskoski, Peltola, Putkinen, & Schäfer, 2017). Similarly, the goal of music-based interventions is not always to make people happy (e.g., other goals include emotion expression, coping strategies, processing grief or trauma; for example, refer to Beer & Birnbaum, 2023). Overall, a key finding from the present work is that music can induce negative emotions in perhaps unexpected ways, which could be considered a side effect of music-based interventions.

In addition to happiness and sadness, we also examined more general positive and negative affect (as a compositive of several different emotion measures). Overall, our findings for positive and negative affect aligned with those for happiness and sadness, but with some nuanced differences. For positive affect, we saw a main effect of time and a main effect of age, which again likely reflect the age-related positivity effect (Carstensen & DeLiema, 2018). However, this age effect was much larger for positive affect than for happiness alone. This finding aligns with previous research, which found that listening to music was largely associated with positive emotions in older adults (Laukka, 2007). For negative affect, we also found an interaction between time and music type, such that memory-evoking music (but not non-memory-evoking music) was associated with increases above baseline at T1 and T2. Finally, we assessed arousal ratings. Arousal was rated significantly above baseline at T1 and T2 for both groups and music conditions. This arousal-related finding has implications for therapeutic uses of music for relaxation purposes: It may be beneficial to select non-personally significant music if the goal of an intervention is to promote relaxation rather than arousal (Tan, Yowler, Super, & Fratianne, 2012).

Overall, one of the goals of the present work was to investigate the role of music-evoked memories in emotion induction by music – is memory-evoking music more likely to evoke emotions than non-memory-evoking music? Here, our data indicate that both types of personally meaningful music can induce emotions, but that memory-evoking music seems more likely to induce sadness and negative affect than non-memory-evoking music. This coincides with research on music-induced nostalgia, which itself is a mixed emotion containing both positive and negative qualities (Barrett et al., 2010; Wildschut, Sedikides, Arndt, & Routledge, 2006). Nostalgia can serve important socioemotional functions, including counteracting loneliness and increasing meaning in life (Routledge et al., 2011; Zhou, Sedikides, Wildschut, & Gao, 2008). Therefore, increased sadness and negative affect associated with memory-evoking music is not per se a detrimental effect, but likely reflects the complexity of emotions associated with music-evoked autobiographical remembering. Regarding models of music-induced affect, such as the BRECVEMA model, our results support "episodic memory" as one mechanism by which music can induce emotions (Juslin, 2013; Juslin, Harmat, & Eerola, 2014). Note that in this model, the author uses "episodic memory" to broadly denote memories "of a specific event in the listener's life" (p. 242, Juslin, 2013), which we refer to here as "autobiographical memories."

Increased sadness and negative affect after listening to memory-evoking music was a consistent observation for both younger and older adults. However, an important age-related effect was that older adults overall reported more happiness and positive affect than younger adults. As mentioned previously, the age-related positivity effect stems from a prominent theory on emotions in aging, termed the Socioemotional Selectivity Theory (Carstensen et al., 2011; Carstensen, Isaacowitz, & Charles, 1999). This theory suggests that this positivity bias is motivation-based, such that as individuals age, they become more motivated to invest in positive experiences. Therefore, it might be the case that the increase in positive affect observed in our study was because older adults *chose* musical selections that were associated with more positive memories. Relatedly, prior work has indicated that older adults are less likely to retrieve negative memories than younger adults (Fernandes, Ross, Wiegand, & Schryer, 2008). To test this, we also investigated the affective content of the memories reported by participants. Overall, most memories were rated as having a positive valence, followed by mixed and negative. This proportion did not differ between younger and older adults. This finding suggests that despite listening to music that was associated with a range of different types of memories (in terms of their affective content), emotional memories with a negative valence may have been more potent than positive ones (i.e., negative memories may have driven the emotion rating results).

Finally, we also investigated the musical selections themselves. Specifically, we looked at the "song-specific age" of the selections and found that older adults chose songs with a higher song-specific age than younger adults. That means that the songs chosen by older adults were released, on average, during their adolescence and young adulthood, as in prior work (Gibbons, 1977). This finding is also related to the large body of research investigating the "reminiscence bump" for music, such that musical preferences and memory-evoking music tends to come from the late adolescence/early adulthood period of life (Jakubowski, Eerola, Tillmann, Perrin, & Heine, 2020). Here, we found that, for older adults, both memory-evoking and non-memory-evoking music generally derived from the period of life associated with the reminiscence bump.

By contrast, the song-specific age for younger adults was significantly lower than for older adults. Younger adults chose musical selections that were released around their birth year through early childhood. This may reflect the phenomenon of "cascading reminiscence bumps," which appear to be unique to music. Although the standard reminiscence bump is during adolescence and early adulthood, individuals also show a second reminiscence bump for music that was popular during their parents' adolescence and early adulthood (Krumhansl & Zupnick, 2013). The musical choices of younger adult participants in this study may therefore reflect this earlier reminiscence bump. Of course, one limitation of this measure of song-specific age is that it does not consider that some of the musical selections may have been "non-era specific" such as folk songs, hymns, etc. When looking at our data, such selections were uncommon (less than 5% of the musical selections were Classical, folk songs, hymns, etc.) and therefore were unlikely to dramatically influence our results.

To conclude, the present work sought to identify the role that music-evoked autobiographical memories play in music-induced emotions, and whether this differs between younger and older adults. Our results indicated an overall age-related positivity effect, supporting prior work in this area and extending it into the realm of music. Importantly, we showed that memory-evoking music is more likely to induce sadness and negative affect than music that is *not* associated with autobiographical memories, and this phenomenon does not appear to differ between younger and older adults. An interesting direction for future work would be to attempt to tease apart what it is about memory-evoking musical selections that drives negative affective responses. In addition to expanded understanding of the mechanisms underlying music-evoked emotions, these findings have important implications for clinicians who design and implement music-based interventions with younger and older adult populations.

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References

Baird, A., Brancatisano, O., Gelding, R., & Thompson, W. F. (2018). Characterization of music and photograph evoked autobiographical memories in people with Alzheimer's disease. *Journal of Alzheimer's Disease*, *66*, 693–706. doi:10.3233/JAD-180627 2

Barrett, F. S., Grimm, K. J., Robins, R. W., Wildschut, T., Sedikides, C., & Janata, P. (2010). Music-evoked nostalgia: Affect, memory, and personality. *Emotion*, *10*(3), 390–403. doi:10.1037/a0019006

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*(1), 1–48. doi:10.18637/jss.v067.i01

Beck, A. T., Steer, R. A., & Carbin, M. G. (1988). Psychometric properties of the beck depression inventory: Twenty-five years of evaluation. *Clinical Psychology Review*, *8*(1), 77–100. doi:10.1016/0272-7358(88)90050-5

Beer, L. E., & Birnbaum, J. C. (2023). *Trauma-informed music therapy: Theory and practice* (1st ed.). New York, NY: Routledge.

Belfi, A. M., Bai, E., Stroud, A., Twohy, R., & Beadle, J. N. (2022). Investigating the role of involuntary retrieval in music-evoked autobiographical memories. *Consciousness and Cognition*, *100* (February), 103305. doi:10.1016/j.concog.2022.103305

Belfi, A. M., Karlan, B., & Tranel, D. (2016). Music evokes vivid autobiographical memories. *Memory*, *24*(7), 979–989. doi:10.1080/09658211.2015.1061012

Belfi, A. M., Moreno, G. L., Gugliano, M., & Neill, C. (2022). Musical reward across the lifespan. *Aging & Mental Health*, *26*(5), 932–939. doi:10.1080/13607863.2021.1871881

Berntsen, D., & Hall, N. M. (2004). The episodic nature of involuntary autobiographical memories. *Memory & Cognition*, *32*(5), 789–803. doi:10.3758/BF03195869

Blood, A. J., & Zatorre, R. J. (2001). Intensely pleasurable responses to music correlate with activity in brain regions implicated in reward and emotion. *Proceedings of the National Academy of Sciences of the United States of America*, *98*(20), 11818–11823. JSTOR Journals. doi:10.1073/pnas.191355898

Bowie, C. R., & Harvey, P. D. (2006). Administration and interpretation of the trail making test. *Nature Protocols*, *1*(5), 2277–2281. doi:10.1038/nprot.2006.390

Burack, O. R., Jefferson, P., & Libow, L. S. (2003). Individualized music: A route to improving the quality of life for long-term care residents. *Activities, Adaptation & Aging*, *27*(1), 63–76. doi:10.1300/J016v27n01_05

Carhart, R., & Jerger, J. F. (1959). Preferred method for clinical determination of pure-tone thresholds. *Journal of Speech and Hearing Disorders*, *24*(4), 330–345. doi:10.1044/jshd.2404.330

Carstensen, L. L., & DeLiema, M. (2018). The positivity effect: A negativity bias in youth fades with age. *Current Opinion in Behavioral Sciences*, *19*, 7–12. doi:10.1016/j.cobeha.2017.07.009

Carstensen, L. L., Isaacowitz, D. M., & Charles, S. T. (1999). Taking time seriously: A theory of socioemotional selectivity. *American Psychologist*, *54*(3), 165–181. doi:10.1037/0003-066X.54.3.165

Carstensen, L. L., Turan, B., Scheibe, S., Ram, N., Ersner-Hershfield, H. . . . Nesselroade, J. R. (2011). Emotional experience improves with age: Evidence based on over 10 years of experience sampling. *Psychology and Aging*, *26*(1), 21–33. doi:10.1037/a0021285

Charles, S. T., Mather, M., & Carstensen, L. L. (2003). Aging and emotional memory: The forgettable nature of negative images for older adults. *Journal of Experimental Psychology: General*, *132*(2), 310–324. doi:10.1037/0096-3445.132.2.310

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. New York, NY: Routledge.

Cohen, P., Cohen, J., Aiken, L. S., & West, S. G. (1999). The problem of units and the circumstance for POMP. *Multivariate Behavioral Research*, *34*(3), 315–346. doi:10.1207/S15327906MBR3403_2

Eerola, T., Vuoskoski, J. K., Peltola, H. R., Putkinen, V., & Schäfer, K. (2017). An integrative review of the enjoyment of sadness associated with music. *Physics of Life Reviews*, *1*, 1–22. doi:10.1016/j.plrev.2017.11.016

El Haj, M., Fasotti, L., & Allain, P. (2012). The involuntary nature of music-evoked autobiographical memories in Alzheimer's disease. *Consciousness and Cognition*, *21*(1), 238–246. doi:10.1016/j.concog.2011.12.005

El Haj, M., Postal, V., & Allain, P. (2012). Music enhances autobiographical memory in mild Alzheimer's disease. *Educational Gerontology*, *38*(1), 30–41. doi:10.1080/03601277.2010.515897

Fairclough, S. H., van der Zwaag, M., Spiridon, E., & Westerink, J. (2014). Effects of mood induction via music on cardiovascular measures of negative emotion during simulated driving. *Physiology & Behavior*, *129*, 173–180. doi:10.1016/j.physbeh.2014.02.049

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. doi:10.3758/BF03193146

Fernandes, M., Ross, M., Wiegand, M., & Schryer, E. (2008). Are the memories of older adults positively biased? *Psychology and Aging*, *23*(2), 297–306. doi:10.1037/0882-7974.23.2.297

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). Mini-mental state. *Journal of Psychiatric Research*, *12*(3), 189–198. doi:10.1016/0022-3956(75)90026-6

Ford, J. H., Addis, D. R., & Giovanello, K. S. (2011). Differential neural activity during search of specific and general autobiographical memories elicited by musical cues. *Neuropsychologia*, *49*(9), 2514–2526. doi:10.1016/j.neuropsychologia.2011.04.032

Gibbons, A. C. (1977). Popular music preferences of elderly people. *Journal of Music Therapy*, *14*(4), 180–189. doi:10.1093/jmt/14.4.180

Guzmán-Vélez, E., Feinstein, J. S., & Tranel, D. (2014). Feelings without memory in Alzheimer disease. *Cognitive and Behavioral Neurology*, *27*(3), 117–129. doi:10.1097/WNN.0000000000000020

Hargreaves, D., & North, A. (2010). Experimental aesthetics and liking for music. In *Handbook of Music and Emotion: Theory, Research, Applications* (Vol. 21, pp. 515–546).

Harrison, L., & Loui, P. (2014). Thrills, chills, frissons, and skin orgasms: Toward an integrative model of transcendent psychophysiological experiences in music. *Frontiers in Psychology*, *5*, 1–6. doi:10.3389/fpsyg.2014.00790

Hilz, M. J., Stadler, P., Gryc, T., Nath, J., Habib-Romstoeck, L. ... Koehn, J. (2014). Music induces different cardiac autonomic arousal effects in young and older persons. *Autonomic Neuroscience*, *183*, 83–93. doi:10.1016/j.autneu.2014.02.004

Izard, C., Dougherty, F., Bloxom, B., & Kotsch, N. (1974). *The differential emotions scale: A method of measuring the meaning of subjective experience of discrete emotions*. Nashville: Vanderbilt University, Department of Psychology.

Jakubowski, K., Belfi, A. M., & Eerola, T. (2021). Phenomenological differences in music- and television-evoked autobiographical memories. *Music Perception*, *38*(5), 435–455. doi:10.1525/mp.2021.38.5.435

Jakubowski, K., Belfi, A. M., Kvavilashvili, L., Ely, A., Gill, M., & Herbert, G. (2023). Comparing music- and food-evoked autobiographical memories in young and older adults: A diary study. *British Journal of Psychology*, *114*(3), 580–604. doi:10.1111/bjop.12639

Jakubowski, K., Eerola, T., Tillmann, B., Perrin, F., & Heine, L. (2020). A cross-sectional study of reminiscence bumps for music-related memories in adulthood. *Music & Science*, *3*, 205920432096505. doi:10.1177/2059204320965058

Juslin, P. N. (2013). From everyday emotions to aesthetic emotions: Towards a unified theory of musical emotions. *Physics of Life Reviews*, *10*(3), 235–266. doi:10.1016/j.plrev.2013.05.008

Juslin, P. N., Harmat, L., & Eerola, T. (2014). What makes music emotionally significant? Exploring the underlying mechanisms. *Psychology of Music*, *42*(4), 599–623. doi:10.1177/0305735613484548

Koelsch, S. (2010). Towards a neural basis of music-evoked emotions. *Trends in Cognitive Sciences*, *14*(3), 131–137. doi:10.1016/j.tics.2010.01.002

Kopiez, R., Weigang, J., Platz, F., & Düvel, N. (2021). Farewell to Holbrook & Schindler's (1989) "song-specific age"? – little evidence for lifelong influence of age-specific musical preferences. *Music & Science*, *4*, 205920432110017. doi:10.1177/20592043211001794

Krumhansl, C. L., & Zupnick, J. A. (2013). Cascading Reminiscence Bumps in Popular Music. *Psychological Science*, *24*(10), 2057–2068. doi:10.1177/0956797613486486

Laukka, P. (2007). Uses of music and psychological well-being among the elderly. *Journal of Happiness Studies*, *8*(2), 215–241. doi:10.1007/s10902-006-9024-3

Levine, B., Svoboda, E., Hay, J. F., Winocur, G., & Moscovitch, M. (2002). Aging and autobiographical memory: Dissociating episodic from semantic retrieval. *Psychology and Aging*, *17*(4), 677–689. doi:10.1037/0882-7974.17.4.677

Martinez-Molina, N., Mas-Herrero, E., Rodríguez-Fornells, A., Zatorre, R. J., & Marco-Pallarés, J. (2019). White matter microstructure reflects individual differences in music reward sensitivity. *Journal of Neuroscience*, *39*(25), 5018–5027. doi:10.1523/JNEUROSCI.2020-18.2019

Mas-Herrero, E., Marco-Pallares, J., Lorenzo-Seva, U., Zatorre, R. J., & Rodriguez-Fornells, A. (2013). Individual differences in music reward experiences. *Music Perception*, *31*(2), 118–138. doi:10.1525/mp.2013.31.2.118

Pereira, C. S., Teixeira, J., Figueiredo, P., Xavier, J., Castro, S. L., Brattico, E., & Pillai, J. (2011). Music and emotions in the brain: Familiarity matters. *PloS ONE*, *6*(11), e27241. doi:10.1371/journal.pone.0027241

Piolino, P., Desgranges, B., Clarys, D., Guillery-Girard, B., Taconnat, L., Isingrini, M., & Eustache, F. (2006). Autobiographical memory, autonoetic consciousness, and self-perspective in aging. *Psychology and Aging*, *21*(3), 510–525. doi:10.1037/0882-7974.21.3.510

Rasmussen, A. S., Johannessen, K. B., & Berntsen, D. (2014). Ways of sampling voluntary and involuntary autobiographical memories in daily life. *Consciousness and Cognition*, *30*, 156–168. doi:10.1016/j.concog.2014.09.008

Reed, A. E., Chan, L., & Mikels, J. A. (2014). Meta-analysis of the age-related positivity effect: Age differences in preferences for positive over negative information. *Psychology and Aging*, *29*(1), 1–15. doi:10.1037/a0035194

Reschke-Hernández, A. E., Belfi, A. M., Guzmán-Vélez, E., & Tranel, D. (2020). Hooked on a feeling: Influence of brief exposure to familiar music on feelings of emotion in individuals with Alzheimer's disease. *Journal of Alzheimer's Disease*, *78*(3), 1019–1031. doi:10.3233/JAD-200889

Routledge, C., Arndt, J., Wildschut, T., Sedikides, C., Hart, C. M. . . . Schlotz, W. (2011). The past makes the present meaningful: Nostalgia as an existential resource. *Journal of Personality and Social Psychology*, *101*(3), 638–652. doi:10.1037/a0024292

Sanflippo, K. R. M., Spiro, N., Molina-Solana, M., & Lamont, A. (2020). Do the shuffle: Exploring reasons for music listening through shuffled play. *PloS ONE*, *15*(2), e0228457. doi:10.1371/journal.pone.0228457

Tan, X., Yowler, C. J., Super, D. M., & Fratianne, R. B. (2012). The interplay of preference, familiarity and psychophysical properties in defining relaxation music. *Journal of Music Therapy*, *49*(2), 150–179. doi:10.1093/jmt/49.2.150

Urry, H. L., & Gross, J. J. (2010). Emotion regulation in older age. *Current Directions in Psychological Science*, *19*(6), 352–357. doi:10.1177/0963721410388395

Wechsler, D. (2001). *Wechsler test of adult reading*. San Antonio, TX, USA: Psychological Corporation.

Wildschut, T., Sedikides, C., Arndt, J., & Routledge, C. (2006). Nostalgia: Content, Triggers, Functions. *Journal of Personality and Social Psychology*, *91*(5), 975–993. doi:10.1037/0022-3514.91.5.975

Zator, K., & Katz, A. N. (2017). The language used in describing autobiographical memories prompted by life period visually presented verbal cues, event-specific visually presented verbal cues and short musical clips of popular music. *Memory*, *25*(6), 831–844. doi:10.1080/09658211.2016.1224353

Zhou, X., Sedikides, C., Wildschut, T., & Gao, D.-G. (2008). Counteracting loneliness: On the restorative function of nostalgia. *Psychological Science*, *19*(10), 1023–1029. doi:10.1111/j.1467-9280.2008.02194.x