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The cognitive and emotional content of music-evoked autobiographical memories in older adults

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Abstract

Music can play a significant role in mitigating cognitive deficits in aging adults. When music is long known and has an emotional significance (i.e., *autobiographical music*), it can trigger memories of past experiences (i.e., Music-Evoked Autobiographical Memories, MEAMs). In this study, we examined the cognitive and emotional content of MEAMs when older adults listened to autobiographical music. To better understand the unique features of MEAMs, we also compared them with responses to non-autobiographical music. Participants ($N = 18$; Mean age = 67.7) were asked to listen to (a) a selection of self-selected autobiographical musical pieces and (b) excerpts of researcher-selected songs. Furthermore, participants completed two surveys on their cognitive and emotional responses to music and took part in follow-up interviews. Results indicated that MEAMs elicited positive emotions, which were strongly felt, and triggered memories of life periods with references to themes such as growing up, love relationships and relationships with family, leisure and working times, and stress releasing. Responses to non-autobiographical music triggered different types of cognitive responses, including assimilating new music sounds, and mainly featured references to negative emotional states. MEAMs should be further investigated as a non-pharmacological treatment for age-related cognitive decline and for clinically diagnosed memory disorders.

Keywords

older adults, autobiographical, memory, music-evoked autobiographical memories, emotion

Over the past two decades, the older population of the United States has grown consistently, reaching 55.8 million in 2020 (16.8% of the U.S. population; Caplan & Rabe, 2023). With the number of older adults increasing, a significant segment of the population lives with some level of cognitive deficits (Hale et al., 2020; Whitson et al., 2018). Research shows that two out of

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three Americans experience a decline in their mental abilities at an average age of approximately 70 years (Hale et al., 2020). As the population ages, music can play a significant role in mitigating cognitive deficits. For instance, researchers have documented that listening to music can trigger memories of past experiences (Belfi et al., 2016; Jakubowski & Ghosh, 2021; Janata et al., 2007; Schulkind et al., 1999). These memories, which are known as music-evoked autobiographical memories (MEAMs; Janata et al., 2007) can be stimulated to reduce memory deficits in effective non-pharmacological interventions (Kaiser & Berntsen, 2023).

Although clinical research on MEAMs is in its early stages, their effectiveness can be explained as follows: MEAMs require little retrieval effort (El Haj et al., 2012; Jakubowski & Ghosh, 2021), are more resilient and vivid than memories evoked by faces (Belfi et al., 2016), and are more easily triggered than memories evoked by word cues (Zator & Katz, 2017). In addition, MEAMs rely on brain areas and cognitive processes that remain relatively intact despite age-related decline and disease (Janata, 2009; Wilkins et al., 2014). Therefore, interventions involving MEAMs can effectively help individuals with cognitive deficits access memories of past experiences (El Haj et al., 2012).

Researchers have further examined the nature and emotional content of MEAMs, while also clarifying the conditions that trigger autobiographical memories. MEAMs can include references to persons, places, lifetime periods, and specific events (i.e., *nature* or *cognitive content*; Janata et al., 2007). They tend to be associated with positive and mixed emotions, such as happiness, youthfulness, and nostalgia (i.e., *emotional content*; Jakubowski & Ghosh, 2021; Janata et al., 2007; Juslin & Vastfjall, 2008). In addition, MEAMs can occur in laboratory settings as participants listen to musical excerpts (Belfi et al., 2016; Janata, 2009; Janata et al., 2007; Zator & Katz, 2017) and in naturalistic environments during routine and undemanding tasks, such as driving, housework, cooking, and relaxing (Jakubowski & Ghosh, 2021). Regardless of the environment, MEAMs are elicited by musical pieces with personal significance (Bartlett & Snelus, 1980; Schulkind et al., 1999). These pieces usually come from periods that are formative and emotionally charged, such as adolescence and young adulthood (Krumhansl & Zupnick, 2013; Zimprich & Wolf, 2016).

Overall, an increasing number of studies have addressed the nature and emotional content of MEAMs with typical adults while also documenting the importance of MEAMs for adults with cognitive decline. In these studies, researchers have mainly involved young adults (Janata et al., 2007; Zator & Katz, 2017) or older people with severe impairments (El Haj et al., 2012; Irish et al., 2006), but they have marginally addressed the nature and emotional content of MEAMs among older adults with "typical" age-related decline (Belfi et al., 2016; Jakubowski & Ghosh, 2021). Researchers have also shown that MEAMs are triggered by familiar and emotionally charged musical pieces (Bartlett & Snelus, 1980; Janata et al., 2007; Schulkind et al., 1999). However, to our knowledge, no studies have directly compared cognitive and emotional responses to both familiar and unfamiliar music, though this comparison could help clarify the unique feature of MEAMs.

Moreover, researchers have mainly explored the cognitive and emotional content of MEAMs by using research-selected pools of excerpts that mainly included popular songs (Belfi et al., 2016; Janata, 2009; Janata et al., 2007; Zator & Katz, 2017). No laboratory studies have used participant self-selected "autobiographical music" (i.e., familiar and autobiographically salient), though experimenter-selected songs may fail to trigger autobiographical memories (Platz et al., 2015; Schulkind et al., 1999). In sum, as music can facilitate memory recall among the aging population, there is a need for studies that provide an in-depth analysis of the responses to autobiographical music among older adults. In addition, there is a need for studies that rely

on participant self-selected autobiographical music because this music can better activate memory recollection despite age-related decline and memory disorders (El Haj et al., 2012).

Drawing on previous research on MEAMs, the purpose of this study was to examine the nature and emotional content of the responses that are evoked when older adults listen to music. Specifically, we addressed the following research questions: What is the cognitive and emotional content of the memories that are triggered by self-selected autobiographical music? To better understand the unique features of music-evoked memories, we decided to compare them with music-evoked responses when listening to non-autobiographical music (i.e., non-familiar and non-autobiographically salient). Therefore, we added two research questions: What is the cognitive and emotional content of music-evoked responses when listening to non-autobiographical music? What are the differences in the responses to autobiographical and non-autobiographical music?

Method

Participants

Eighteen older adults from South Florida were recruited through a university Institutional Review Board (IRB)-approved research study. Participants received monetary compensation. The sample consisted of 11 female (61%) and 7 male (39%). Their ages ranged between 60 and 79 years ($M = 67.72$, $SD = 6.35$). Participants exhibited typical cognitive aging, as assessed by the Montreal Cognitive Assessment tool (MoCA; Nasreddine et al., 2005; $M = 27.86$, $SD = 2.69$). Table 1 shows participants' ethnicity, language, levels of education, and income.

Half of the participants ($n = 9$, 50%) received formal music training, which ranged between 1 and 12 years of music classes ($M = 4.25$, $SD = 3.53$). Regardless of their musical background, participants were engaged in musical activities. They often listened to music during their childhood ($n = 12$, 66.7%) and adolescence/early adulthood ($n = 15$, 83.3%). In addition, participants estimated a current average of 7.67 ($SD = 5.25$) h of music listening per week and indicated that music played a significant role in their lives ($n = 15$, 83.3%).

Procedure

This study was part of a larger research project where we explored participants' neural connectivity when listening to music. The larger research project unfolded in several steps (Figure 1S, supplemental materials). First, participants completed an on-line questionnaire that included both open-ended and multiple-choice questions. We asked participants to specify four autobiographical musical pieces, to answer questions on their cognitive and emotional responses to their self-selected music, and to provide socio-demographic information. Second, each participant was invited to our laboratory. In this setting, a team of neurologists administered the MoCA (Nasreddine et al., 2005), a screening tool for detecting mild cognitive impairment.

We asked participants to listen to their music choices, and also to listen to a non-autobiographical musical excerpt. Both the autobiographical and non-autobiographical excerpts lasted 12 min each and included three pieces. In the first questionnaire, participants identified four autobiographical musical pieces. Although four selections were requested, only three were used for listening, with the fourth serving as a backup in case one could not be retrieved. For the non-autobiographical musical excerpt, we combined three pieces that do not belong to common Western repertoires (i.e., Balinese Gamelan, Mongolian throat singing, and Zimbabwean

Table 1. Participants' Demographics.

	n	%
Race/ethnicity		
White non-Hispanic	13	72.2
White Hispanic	3	16.7
Black or African American	1	5.6
Prefer not to say	1	5.6
Native language		
English	14	77.8
Spanish	3	16.7
Bilingual	1	5.6
Income		
$20K–50K	3	16.7
$60K–90K	2	11.1
$100K–140K	5	27.8
$150+	3	16.7
Prefer not to say	5	27.8
Education		
Some high school	2	11.1
Bachelor's	8	47.1
Master's	3	16.7
PhD	2	11.1
Trade	2	11.1

Mbira music, Figure 1S). We chose non-Western repertoires to avoid familiarity and associations with the music, as recommended by (personal communication). Participants listened to both autobiographical and non-autobiographical music in a functional magnetic resonance imaging (fMRI) scanner using headphones. While participants listened to music stimuli, we examined their neural connectivity through brain imaging techniques. The results from brain imaging will be reported elsewhere. Third, after the laboratory sessions, participants completed a second on-line questionnaire that included both open-ended and multiple-choice questions. We used this second questionnaire to collect cognitive and emotional responses to the musical excerpts that participants listened to during the brain imaging sessions. Finally, we conducted follow-up phone interviews.

Research design and instruments

This article focuses on participants' cognitive and emotional responses to autobiographical and non-autobiographical music. To explore these aspects, we relied on a concurrent mixed-methods design (Creswell & Plano Clark, 2011). We thus simultaneously collected quantitative and qualitative data through two on-line questionnaires. We then conducted follow-up phone interviews to supplement the qualitative data set.

First questionnaire. In the first questionnaire (i.e., before brain imaging sessions), participants provided a selection of four musical pieces, which could include songs and/or instrumental music. Participants could identify their chosen music by title and artist and, if desired, by a specific recording. However, we asked them to meet two requirements: (a) to choose music that

they had known for over 20 years and (b) to choose music that brought out an autobiographical reaction. We specified that an autobiographical reaction happens when a song/music is associated with specific people, places, events, or time periods in their life.

Moreover, we asked participants to answer a series of questions on each self-selected musical piece. Drawing on Janata et al.'s (2007) study, these questions aimed to assess the cognitive and emotional content of participants' memories when listening to their four autobiographical pieces. Specifically, a question asked participants to indicate the nature of their memories by selecting one or more of the following categories: events, periods, persons, and places. Likert-type questions with univalent scales asked participants to indicate the presence and overall valence of their emotional responses. That is, on a 7-point scale ranging from 1 = *strongly disagree* to 7 = *strongly agree*, participants indicated whether each self-selected piece evoked an emotional response in association with the memory of an event, period, person, or place. On a 3-point scale ranging from 3 = *pleasing* to 1 = *displeasing*, participants indicated whether their emotional responses to each piece was overall pleasing, neutral/mix, or displeasing. In addition, we provided participants with a list of 34 emotion adjectives (e.g., happy, youthful, and sad) and asked them to select all the adjectives that best described their emotional responses to each self-selected piece. We used open-ended questions requiring written responses to collect descriptions of the events, periods, people, and places that were evoked by autobiographical music.

We concluded the first questionnaire with questions to collect typical demographic and general music background information. We asked participants to specify their musical training and estimate the number of hours of music listening per week.

Second questionnaire. We used the second questionnaire (i.e., after brain imaging sessions) to collect participants' cognitive and emotional responses to both autobiographical (i.e., 3 musical pieces) and non-autobiographical music during the brain imaging sessions. We therefore relied on a set of questions that were similar to those in the first questionnaire, though we excluded the categorical question regarding types of emotional responses (i.e., sad, happy, and youthful). In addition, we included a Likert-type question with a 5-point univalent scale (ranging from 1 = *very little* to 5 = *very strongly*) on the strength of emotional responses. These changes facilitated subsequent comparisons among responses to both autobiographical and non-autobiographical music during the brain imaging sessions.

To explore responses to non-autobiographical music, we included both open-ended and Likert-type questions with univalent scales. For each non-autobiographical piece, we used an open-ended question to collect participants' thoughts when listening to that excerpt. Moreover, participants indicated their familiarity with each non-autobiographical piece on a 5-point scale (ranging from 1 = *completely unfamiliar* to 5 = *completely familiar*). Using a 7-point scale (ranging from 1 = *strongly dislike* to 7 = *strongly like*), participants expressed their preferences for the non-autobiographical excerpts. A Likert-type question with a 4-point univalent scale (ranging from 1 = *no association* to 5 = *strong autobiographical associations*) asked participants to indicate whether the non-autobiographical pieces evoked memories. Finally, to assess the presence, overall valence, and strength of emotional responses to each non-autobiographical excerpt, we used the same Likert-type questions that we included in the first questionnaire for collecting emotional responses to the autobiographical pieces (see supplemental materials for all questionnaires).

Phone interviews. Semi-structured phone interviews lasted up to 30 min. Participants were asked to provide more details about the memories and thoughts evoked by autobiographical and non-autobiographical music during the brain imaging sessions. The interviews were recorded and transcribed by an automatic transcription service.

Data analysis

We analyzed all quantitative and qualitative data separately. We performed statistical analyses in IBM SPSS 27.0 (IBM Corp., 2020), while using NVivo 13 (Lumivero, 2020) to analyze qualitative data. We then merged the results of the analyses, using qualitative data to enrich quantitative results (Creswell & Plano Clark, 2011).

Research question 1: responses to autobiographical music. To assess the cognitive and emotional content of the responses to autobiographical music, we performed the following set of qualitative and quantitative analyses.

Analysis of Cognitive Responses. We started by assessing how participants categorized their music-evoked memories (i.e., nature of cognitive responses) outside of the laboratory setting (i.e., first questionnaire, before brain imaging sessions). For each participant, we calculated the proportion of responses within each response category (i.e., event, period, person, and place). For instance, we established the total number of times a participant selected the category *event* across the four self-selected songs. We divided this number by 4 (i.e., total number of self-selected pieces) to obtain the set of individual response distributions. We then averaged the set of individual response distributions to generate Figure 2a. We repeated the same steps to assess how participants categorized their music-evoked memories in the laboratory setting (i.e., second questionnaire, after brain imaging sessions; Figure 2b). However, to obtain the set of individual response distributions, we divided participants' responses by 3 (i.e., total number of randomly selected pieces in the laboratory setting).

We continued by analyzing open-ended questions and follow-up interviews to determine the length and dominant themes (i.e., content of cognitive responses) of the descriptions of music-evoked memories. After removing filler words (i.e., "um," "uh," and "like"), we computed the length of each answer in Excel by calculating the number of words that participants used. We then performed thematic analysis to identify and report patterns (themes) in our set of narrative data. Thematic analysis was an ongoing and iterative process that unfolded in six steps (Braun & Clarke, 2006). First, we became familiar with both answers to open-ended questions and transcripts of phone interviews by reading the data and taking notes about recurring patterns. Second, we named chucks of data with codes (i.e., labels that summarized the content of each textual segment; Charmaz, 2014). Third, we compared codes with codes to group them into broader and meaningful categories (i.e., groups of codes sharing properties and characteristics; Charmaz, 2014). Fourth, by comparing categories and iteratively revising codes and categories, we identified themes (i.e., overarching groups that captured meaningful patterns in the data; Charmaz, 2014). We then revised and finalized our themes in the fifth step of the analysis before producing a final report.

Analysis of Emotional Responses. To assess the type of emotional responses in the first questionnaire, we computed the proportion of times participants selected a specific emotion among a list of 34 adjectives covering both positive and negative emotional states. To assess the presence and overall valence of emotional responses to autobiographical music in the first questionnaire, we computed average ratings across participants. Similarly, we computed average ratings across participants to assess the presence, overall valence, and strength of emotional responses to autobiographical music in the second questionnaire. We then used the one-sample *t*-test to determine whether average ratings were significantly higher than neutral values. In addition, we averaged the set of individual response distributions to generate the Plots in Figure 3 and 4. Finally, we relied on paired-samples *t*-test to analyze differences in the presence and overall valence of emotional responses to autobiographical music in and outside of the laboratory setting.

Research question 2: responses to non-autobiographical music. Analysis of Cognitive Responses. To assess the cognitive content of the responses to non-autobiographical music, we first checked whether participants experienced an autobiographical association with that music. We therefore calculated the proportion of responses within each response category (i.e., no association, loose association, et al.). We divided this number by 3 (i.e., total number of non-autobiographical pieces) to obtain the set of individual response distributions. We then averaged the set of individual response distributions to generate Figure 6a. In addition, we used thematic analysis to determine the content of the thoughts that were elicited by non-autobiographical music.

Analysis of Emotional Responses. We computed average ratings across participants to assess the presence, overall valence, and strength of emotional responses to non-autobiographical music (Figure 6b–d). We then used the one-sample *t*-test to determine whether average ratings were significantly higher than neutral values.

Results

Autobiographical music

Description of autobiographical excerpts. Participants selected songs that mainly belonged to rock (44.4%) and pop (29.2%) music (Figure 1a). Moreover, 55.6% ($n = 40$) of these pieces belonged to a single music genre, while 44.4% ($n = 32$) combined a variety of musical influences. When pieces belonged to a single genre, the most represented genres were rock (22.5%) and classical (12.5%; Figure 1b). Pieces that crossed genres showed unique combinations of musical influences (i.e., alternative/indie, pop and rock; country and blues; rock and jazz; and new age and rock). Finally, participants' choices were mainly representative of the music from the 1970s (38.8%) and 1980s (13.8%; Figure 1c).

Responses to autobiographical music (RQ 1). Cognitive Content. On average, participants indicated that 77.7% of their selected musical pieces elicited memories of a period (Figure 2a). The laboratory setting did not significantly alter participants' responses (Figure 2b). Moreover, period-related memories were mainly associated with adulthood (ages 30 and up; 26.4%), adolescence (ages 11–19; 25%), and young adulthood (ages 20–30; 23.6%), but less commonly with childhood (up to 10 years of age; 2.7%). Similarly, memories of events, people, and places were mainly associated with adulthood (52.9%), young adulthood (23.5%), and adolescence (17.6%). When asked to describe their music-evoked memories, participants provided the greatest number of details for period-related memories (Mean of used words = 50.64). Conversely, they provided the shortest descriptions when referring to people ($M = 6.18$) and places ($M = 6.5$).

Thematic analysis of open-ended questions and follow-up interviews highlighted as follows (Table 1S, supplemental materials): Music-evoked *memories of events* included two main themes: (a) references to leisure activities, such as going to a concert for the first time and relaxing after a marathon, and (b) events involving family members. For instance, music helped participants remember happy times and memorable experiences with their parents. One participant recalled, "My parents took me to the Duve-in Theater. We saw the movie 'A Hard Day's Night.' We bought popcorn and cokes. I loved the music." Music also evoked memories of family bonding moments, such as visiting relatives and spending time with cousins. Other memories of events and family members included references to participants' adulthood. Participants mentioned both tragic happenings (son's funeral) and positive experiences (driving together) that involved their

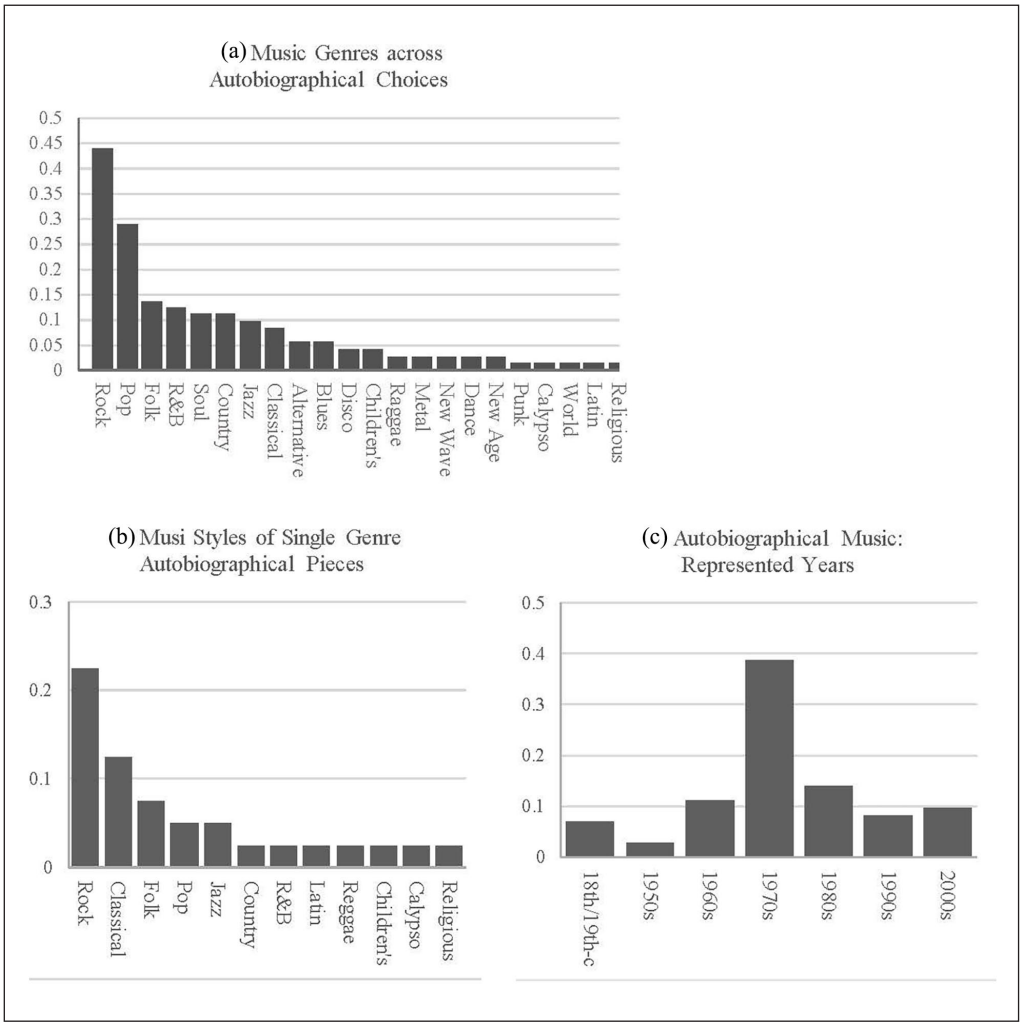

Figure 1. Characteristics of Autobiographical Pieces. These Plots are based on participants' answers to Questionnaire 1 (before brain imaging sessions). (a) Distribution of average proportions of music genres across autobiographical music excerpts. (b) Distribution of average proportions of music genres across autobiographical music excerpts that belonged to a single music genre. (c) Distribution of average proportions of decades across autobiographical music excerpts.

children. Several music-evoked memories included references to weddings and anniversary celebrations.

Music-evoked *memories of a period* included four themes: (a) growing up, (b) love relationships and relationships within family, (c) leisure and working times, and (d) stress releasing. Music helped participants recall "period(s) of discovery" as they transitioned from adolescence to young adulthood. Several memories were associated with the experience of going to college and moving abroad to attend higher institutions. Music further evoked period-related memories that involved relationships with both significant others and family members. For instance, period-related memories included references to becoming a young parent or losing children.

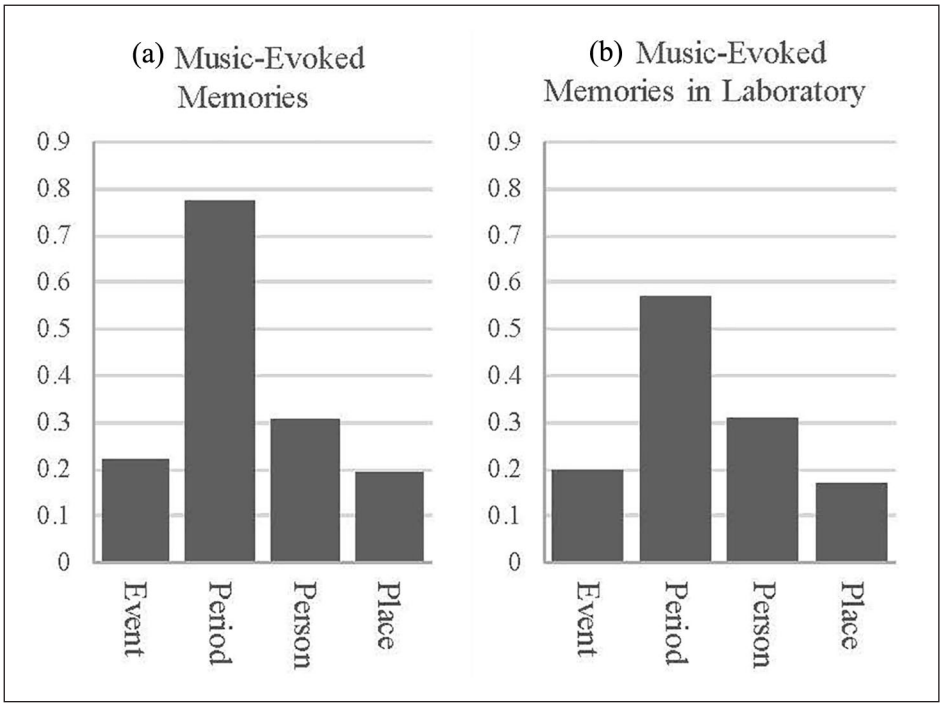

Figure 2. Nature of Music-Evoked Memories. (a) Distribution of average proportions of responses across categories of memories outside of the laboratory setting (Questionnaire 1, before brain imaging sessions). Participants were asked to identify 4 autobiographical pieces. For each piece, participants could select one of more response categories. (b) Distribution of average proportions of responses across categories of memories in the laboratory setting (Questionnaire 2, after brain imaging sessions). In the laboratory setting, participants listened to 3 randomly selected autobiographical pieces. For each piece, participants could select one of more response categories.

Several memories were associated with the experience of dating and building relationships during young adulthood and the experience of going through a divorce and finding a new freedom after years of marriage. Moreover, music elicited memories of early job experiences. One participant recalled,

> I was out in the world, having dropped out of college to take my first newspaper job. This song I associate with young adulthood in Florida, when the world was bright and full of joy and I was a father, and I got to write for a living.

Music also evoked memories of leisure times during adolescence and young adulthood, when participants used to party, drive around, and listen to songs with their friends. Finally, participants selected songs that have helped them regulate their moods during stressful moments throughout their lives.

Participants did not provide extensive details when asked to describe music-evoked *memories of a person*. They mainly used descriptive nouns, including friends, daughter, husband/wife, and mother/father. Similarly, participants provided short descriptions of music-evoked *memories of a place*. These memories mainly included references to special places during childhood

and adolescence. For instance, participants mentioned nightclubs they attended with friends in the summer. In addition, they recalled their childhood hometowns, which have become a sort of "lost paradise." One participant explained, "(This song reminds me of) a small town in the mountains. Though I was anxious and unhappy at the time, in memory it is a time of bucolic paradise."

Emotional Content. Before the brain imaging sessions (i.e., first questionnaire), participants indicated as follows: On a 7-point scale (1 = *strongly disagree*, 4 = *neither agree nor disagree*, 7 = *strongly agree*), participants mainly agreed (25%) or strongly agreed (55.6%) that their preferred songs evoked an emotional response in association with the memory of an event, period, person, or place (Figure 3a). The average rating ($M = 5.77$, $SD = 1.78$) was significantly higher than the neutral value of 4, $t(17) = 4.23$, $p < .001$, $g = .95$. Moreover, on a 3-point scale (3 = *pleasing*, 2 = *neutral/mix*, 1 = *displeasing*), participants indicated that their emotional responses were mainly pleasing (79.2%) or neutral/mix (18.1%; Figure 3b). The average rating ($M = 2.75$, $SD = .29$) was significantly higher than the neutral value of 2, $t(17) = 10.71$, $p < .001$, $g = 2.41$. Among the 34 adjectives covering both positive and negative emotional states (Figure 3c), the most common choices were *happy* (69.4%), *joyous* (48.6%), *excited* (47.2%), and *inspired* (40.3%).

The laboratory setting did not significantly alter participants' emotional responses (Figure 2 S, supplemental materials). After listening to their autobiographical pieces in the laboratory (i.e., second questionnaire), the majority of participants (66.7%) strongly agreed that their preferred songs still evoked an emotional response in association with the memory of an event, period, person, or place (Figure 4a). The average rating in the laboratory ($M = 6.47$, $SD = .81$) was significantly higher than the neutral value of 4, $t(15) = 12.15$, $p < .001$, $g = 2.88$. In addition, the average rating in the laboratory did not significantly differ from the average rating outside of the laboratory, $t(15) = -1.59$, $p = .133$, $g = -.38$.

After the brain imaging sessions, participants also indicated that their emotional responses were mainly pleasing (79.6%; Figure 4b). The average rating in the laboratory ($M = 2.87$, $SD = .34$) significantly differed from the neutral value of 2, $t(15) = 10.25$, $p < .001$, $g = 2.43$. In addition, the average rating in the laboratory ($M = 2.87$, $SD = .34$) did not significantly differ from the average rating outside of the laboratory, $t(15) = -1.95$, $p = .07$, $g = -.47$. After the brain imaging sessions, participants rated the strength of their emotional responses. On a 5-point scale (1 = *very little*, 3 = *somewhat*, 5 = *very strongly*), participants indicated that they experienced a very strong (66.7%) or strong (14.8%) emotional response to their autobiographical music during the brain imaging session (Figure 4c). The average rating ($M = 4.66$, $SD = .53$) was significantly higher than the neutral value of 3, $t(15) = 12.57$, $p < .001$, $g = 2.98$.

Non-autobiographical music

Non-autobiographical excerpts: familiarity and preference. After the brain imaging sessions (i.e., second questionnaire), we asked participants to rate the non-autobiographical pieces in terms of familiarity and preference. On a 5-point scale (1 = *completely unfamiliar*, 3 = *only somewhat familiar*, 5 = *very familiar*), the majority of participants confirmed that the non-autobiographical excerpts were completely unfamiliar (50%), fairly unfamiliar (9.2%), or only somewhat familiar (20.3%; Figure 5a). The average rating ($M = 1.87$, $SD = .75$) was significantly lower than the neutral value of 3, $t(15) = -5.93$, $p < .001$, $g = -1.40$. Moreover, on a 7-point scale (1 = *strongly dislike*, 4 = *neither dislike nor like*, 7 = *strongly like*), the majority of participants (25.9%) indicated that they neither liked nor disliked the non-autobiographical excerpts. Some participants (18.5%) indicated they somewhat liked that music, while others (16.7%) expressed

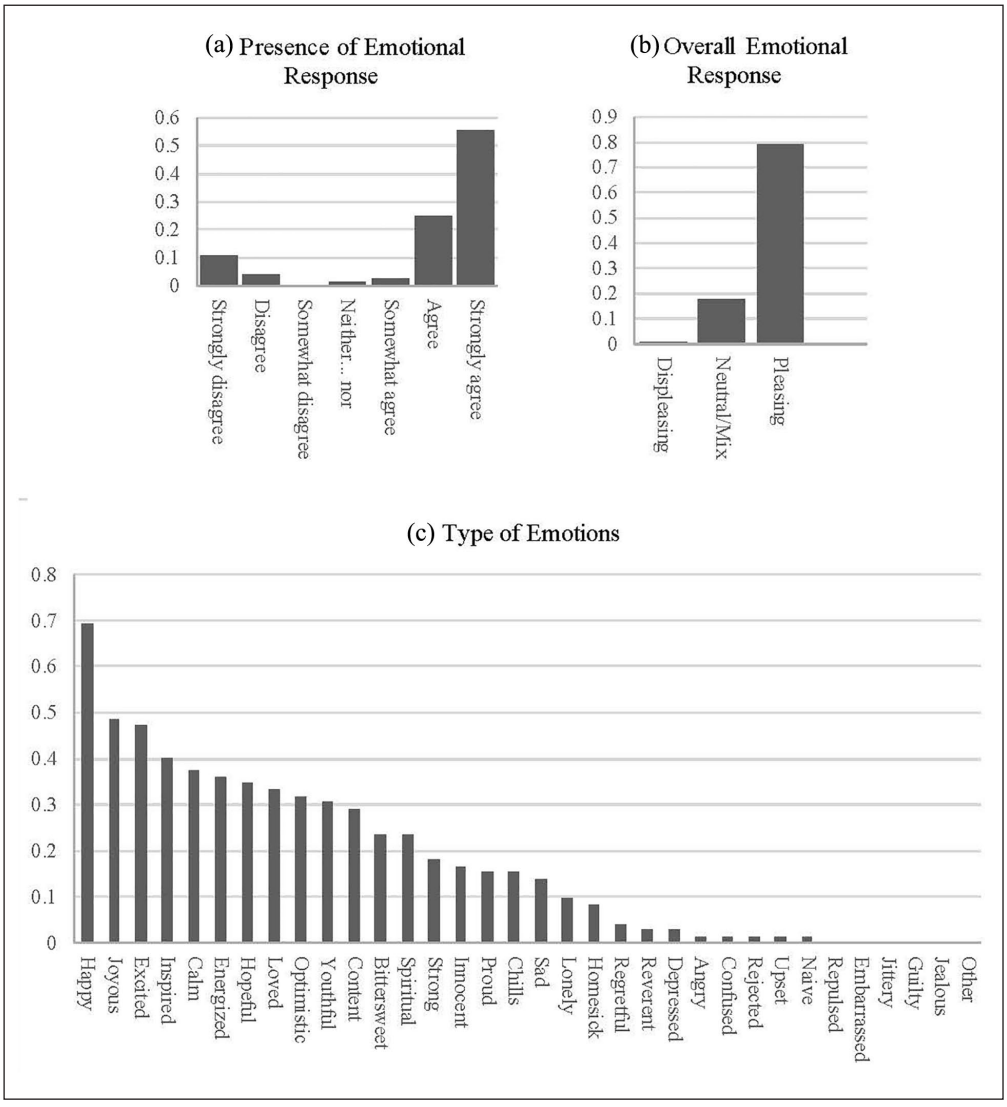

Figure 3. Emotional Content of Music-Evoked Memories outside of the Laboratory Setting. These Plots are based on participants' responses to Questionnaire 1 (before brain imaging sessions). (a) Distribution of average proportions of responses to the statement "Hearing this song sometimes evokes an emotional reaction that is associated with an event, period, person, or place." (b) Distribution of average proportions of responses to the question "Overall, which of the following emotions do you associate with your memories of this song/music? Please indicate one." (c) Distribution of average proportions of autobiographical songs that were identified with various emotions.

a strong dislike (Figure 5b). The average rating ($M = 2.54$, $SD = .98$) was significantly lower than the neutral value of 4, $t(15) = -5.95$, $p < .001$, $g = -1.41$

Responses to non-autobiographical music (RQ 2). Cognitive Content. On a 4-point scale (1 = *no association*, 3 = *somewhat*, 5 = *strongly autobiographical*), participants indicated that the non-autobiographical pieces evoked either no association (66.7%) or loose associations

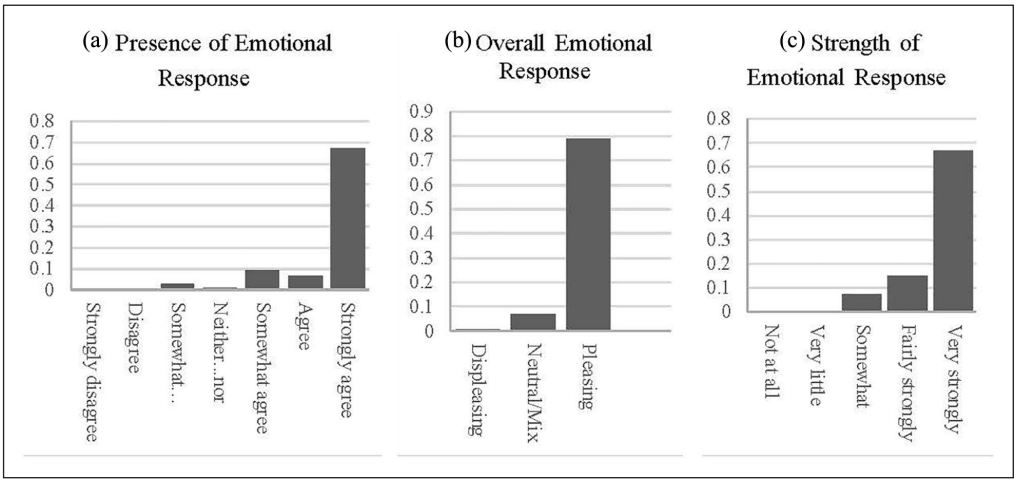

Figure 4. Emotional Content of Music-Evoked Memories in the Laboratory Setting. These Plots are based on participants' responses to Questionnaire 2 (after brain imaging session). (a) Distribution of average proportions of responses to the statement "Hearing this song sometimes evokes an emotional reaction that is associated with an event, period, person, or place." (b) Distribution of average proportions of responses to the question "Overall, which of the following emotions do you associate with your memories of this song/music? Please indicate one." (c) Distribution of average proportions of responses to the question "How strongly do you experience these emotions when you hear this song?"

(16.7%) with an event, period, person, and place (Figure 6a). Nevertheless, participants were asked to describe their thoughts when listening to non-autobiographical music. Two main themes emerged from these descriptions: (a) identifying the music and (b) describing emotional states. Participants tried to identify the genre(s) and origin of the non-autobiographical musical excerpt. One participant recalled, "I started to analyze the music, trying to determine the genre. Is this African? Is it indigenous?" Overall, the process of identifying the musical excerpt included two main mental processes. Participants first focused on the musical qualities of the excerpt. For instance, some noticed its percussive quality. Others focused on the instruments that produced those sounds. One participant tried to "imagine what the composer of the music was trying to convey." Next, participants compared the excerpt with other music styles, trying to categorize it within more familiar genres. For instance, one participant recalled, "I vividly remembered trying to compare the beat of it to Soca music."

Moreover, participants described their emotional responses to the non-autobiographical excerpt. Several participants experienced neutral reactions, which were "neither pleasant nor unpleasant." However, approximately half of them did not like the excerpt because they did not know the music and because it was "too loud and annoying." Therefore, they hoped that the excerpt would end soon.

Emotional Content. On a 7-point scale (1 = *strongly disagree*, 4 = *neither agree nor disagree*, 7 = *strongly agree*), participants indicated whether they had an emotional response when listening to non-autobiographical music (i.e., presence of emotional response). Participants mainly agreed (27.8%) or strongly agreed (22.2%) that non-autobiographical music elicited an emotional response, while 5 participants (27.8%) neither agree nor disagree with the statement (Figure 6b). Overall, the average rating ($M = 4.89$, $SD = 1.87$) was not significantly higher than the neutral value of 4, $t(17) = 2.01$, $p = .06$, $g = .45$.

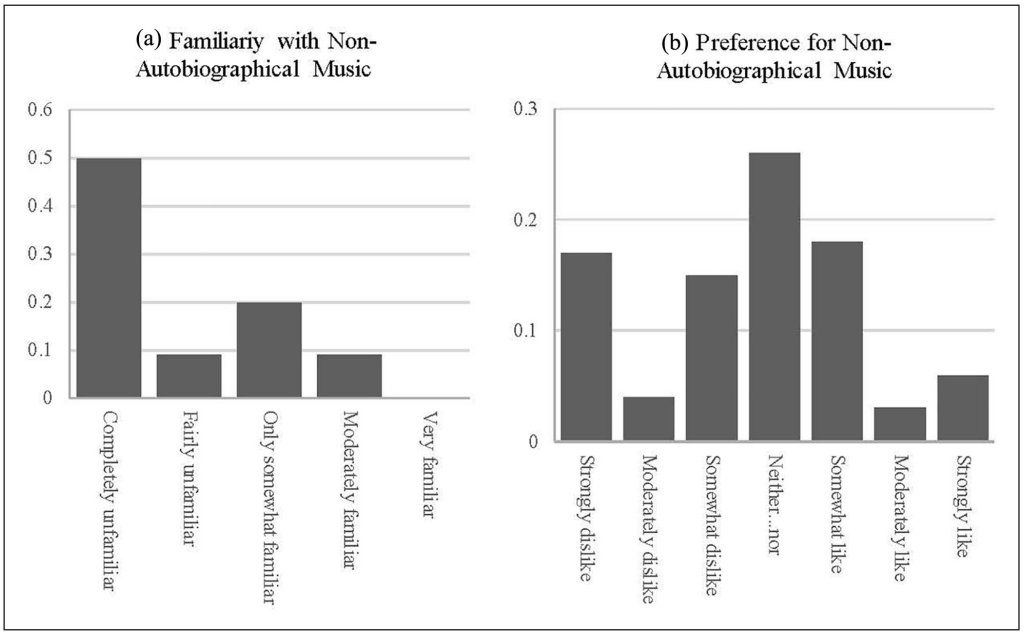

Figure 5. Non-Autobiographical Music: Familiarity and Preference. These Plots are based on participants' answers to Questionnaire 2 (after brain imaging sessions). (a) Distribution of average proportions of responses to the question, "How familiar you are with the music you have just heard?" (b) Distribution of average proportions of responses to the question, "How much do you like the music you have just heard?"

Participants were further asked to categorize their response on a 3-point scale (3 = *pleasing*, 2 = *neutral/mix*, 1 = *displeasing*). Participants who experienced an emotional response ($n = 17$) indicated that this response was mainly neutral/mix (41.2%; Figure 6c) or displeasing (41.2%). However, the average rating ($M = 1.76$, $SD = .75$) was not significantly different from the neutral value of 2, $t(16) = -1.28$, $p = .21$, $g = -.29$. The crosstabulation between presence and overall valence of emotional responses indicated as follows: When participants experienced emotional responses ($n = 10$; *somewhat agree* to *strongly agree*), these responses were mainly positive ($n = 3$) or negative ($n = 6$). When participants chose the middle point ($n = 4$; *neither agree nor disagree*), they experienced neutral emotions. When participants did not experience an emotional response ($n = 3$), they also indicated that their responses were neutral.

Moreover, on a 5-point scale (1 = *very little*, 3 = *somewhat*, 5 = *very strongly*), participants indicated that their emotional responses were mainly somewhat strong (33.3%) or very strong (27.8%; Figure 6d). However, the average rating ($M = 3.22$, $SD = 1.43$) was not significantly higher than the neutral value of 3, $t(17) = .65$, $p = .52$, $g = .14$. The crosstabulation between presence and strength of emotional responses confirmed that participants rated their responses as strong ($n = 2$) or very strong ($n = 5$) when they also agreed and strongly agreed that music evoked an emotional response.

Differences in the responses to autobiographical and non-autobiographical music (RQ 3)

Cognitive responses. Table 2 shows differences in cognitive responses to autobiographical and non-autobiographical music, summarizing the main themes that emerged from participants'

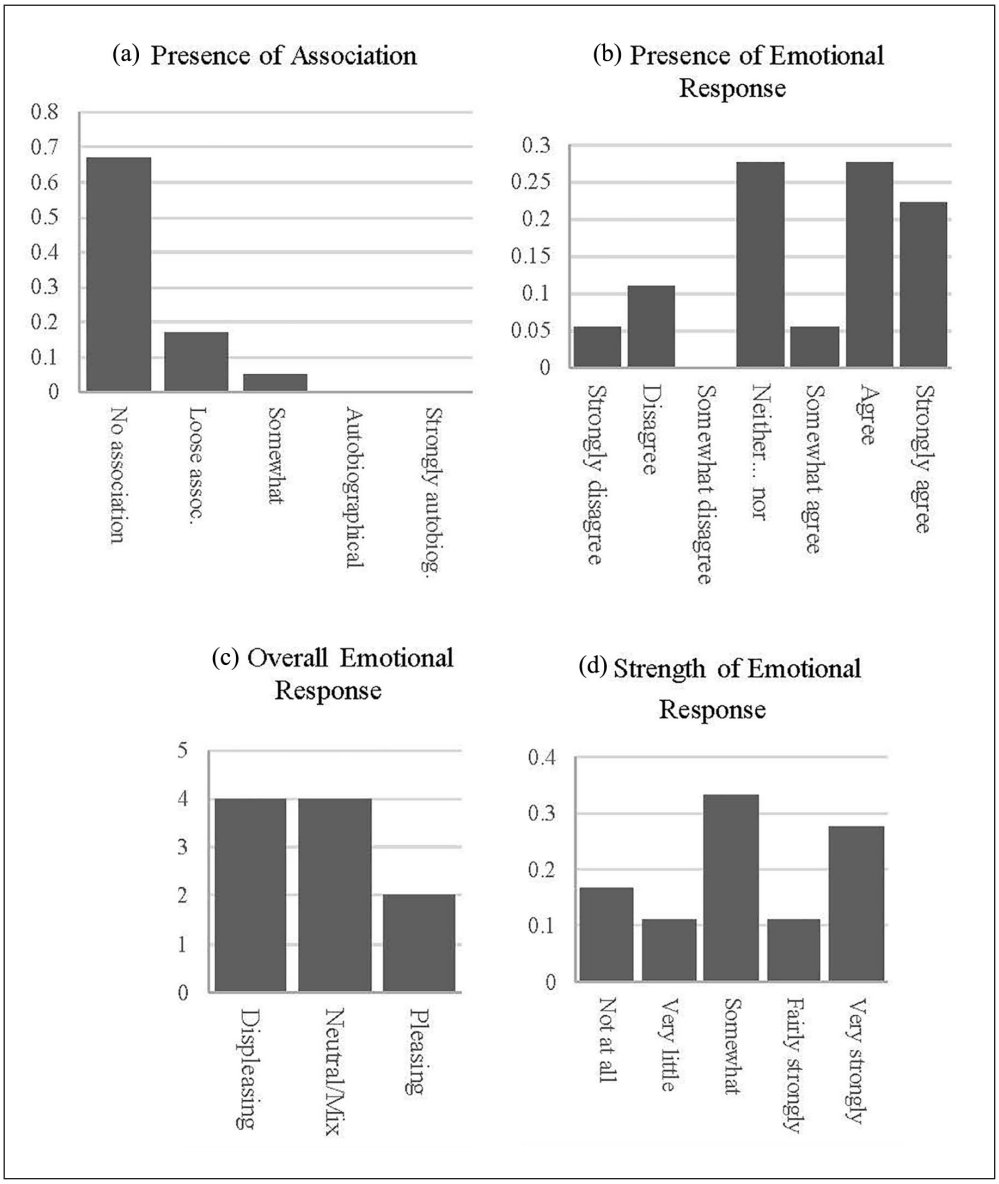

Figure 6. Responses to Non-Autobiographical Music. These Plots are based on participants' responses to Questionnaire 2 (after brain imaging sessions). (a) Distribution of average proportions of responses to the question "Please indicate whether this music evoked an autobiographical association." (b) Distribution of average proportions of responses to the statement "Hearing this song sometimes evokes an emotional reaction that is associated with an event, period, person, or place." (c) Distribution of average proportions of responses to the question "Overall, which of the following emotions do you associate with this song/music? Please indicate one." (d) Distribution of average proportions of responses to the question "How strongly do you experience these emotions when you hear this music?"

Table 2. Themes in Cognitive Responses to Music.

Autobiographical music	Non-autobiographical music
Memories of periods	*Identifying the music*
Growing up	Focusing on the musical quality of the excerpts
Love relationships and relationships within family	
Leisure and working times	Comparing the excerpts with other music styles
Stress releasing during difficult times	
Memories of events	*Describing emotional states*
Leisure activities	Neutral reactions
Events involving family members	Negative reactions
Memories of a person(s)	
References to specific people	
Memories of places	
Special places during childhood and adolescence	

responses to open-ended questions and phone interviews. Overall, autobiographical music mainly triggered memories of periods, which included themes such as growing up, love relationships and relationships with family, leisure and working times, and stress releasing. In contrast, responses to non-autobiographical music lacked examples of personal memories. Participants described their attempts to identify unfamiliar musical excerpts and described their emotional responses, which were mainly negative or neutral.

Emotional responses. Figure 7 shows differences in emotional responses to autobiographical and non-autobiographical music as emerged from participants responses to the second questionnaire (i.e., after brain imaging sessions). Overall, the majority of participants strongly agreed that autobiographical music-evoked emotional responses, mainly rating these responses as pleasing and very strong. When participants assessed the presence, valence, and strength of emotional responses to non-autobiographical music, the average ratings were not significantly higher than neutral values. That is, participants did not experience strong emotional responses to non-autobiographical music. If they did feel emotional responses, these were mainly neutral (or displeasing).

Discussion and conclusions

In this study, we examined the nature and emotional content of music-evoked responses in eighteen older adults. In relation to the responses to autobiographical music (Research Question 1), our findings indicate that older adults tend to recall autobiographical memories when they listen to music from their young adult and mid-adult years. As the average age of our participants was 67 years, the music they chose was most representative of the 1970s and 1980s. Thematic analysis of the answers to open-ended questions and interviews further revealed that older adults mainly described memories from their adulthood, young adulthood, and adolescence, with the fewest associations related to childhood. Our findings echo that of earlier research (Bartlett & Snelus, 1980; Krumhansl, 2017; Platz et al., 2015; Schulkind et al., 1999; Zimprich & Wolf, 2016), reinforcing that music-evoked memories are inextricably linked to the years of one's adult identity development.

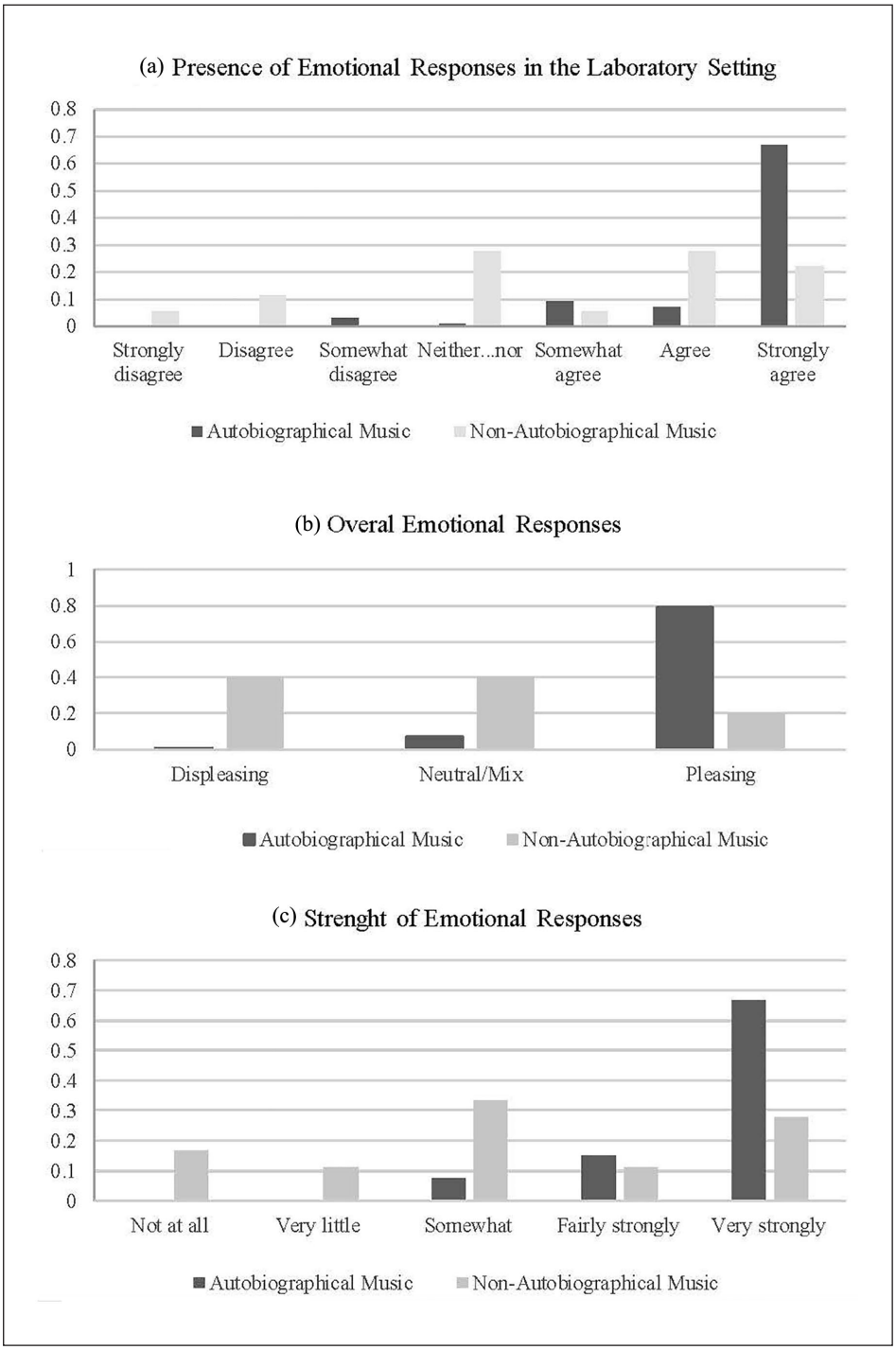

Figure 7. Emotional Responses during Brain Imaging Sessions.

Moreover, older adults associated MEAMs with a lifetime period more frequently than with a person(s) or event(s). Thematic analysis of the answers to open-ended questions and interviews confirmed that participants provided the greatest number of details for period-related memories. This contrasts with Janata et al.'s (2007) findings, which showed that college age students mainly associated MEAMs with people or relationships. A possible explanation for this contrast is that different internal drives affect adult behavior and needs throughout the lifespan (Cohen, 2000, 2005). Older adults tend to reflect retrospectively about their lives, especially after 60 years of age. Conversely, college students are focused on building their careers and relationships. Therefore, adult memories are likely to include different aspects across the lifespan (Conway & Pleydell-Pearce, 2000).

Results also showed that participants mainly used adjectives such as happy, joyful, and excited to describe their emotional responses to autobiographical music. Consistent with previous studies (Jakubowski & Ghosh, 2021; Janata et al., 2007; Juslin & Vastfjall, 2008), these findings reveal that MEAMs tend to resiliently elicit emotions and, further, that these emotions are overwhelmingly positive. Interestingly, although participants indicated that their MEAMs overall evoked positive emotional responses, they also shared stories of sad periods in their answers to open-ended questions and interviews (e.g., losing a son, going through a divorce, and stressful life moments). These few sad narratives were accompanied by mixed/neutral emotional responses, but not indicated as displeasing. Perhaps, these musical selections helped participants regulate their mood and emotions during challenging times.

In relation to the responses to non-autobiographical music (Research Question 2), results overwhelmingly showed that older adults experienced no association or only a loose association with an event, period, person, or place when listening to unfamiliar music. However, while the majority indicated no association, a substantial number experienced a strong emotional response to the music, with many of them indicating a displeasing emotional response. Some participants further explained that the non-autobiographical music was too loud, though both autobiographical and non-autobiographical excerpts in the laboratory setting had the same decibel levels. Consistent with early studies (Cullari & Semanchic, 1989), this finding confirmed a relationship among loudness, familiarity, and preference. That is, when individuals do not like a song or are unfamiliar with a piece of music, they tend to perceive it as louder. The narrative responses further confirmed that the non-autobiographical musical excerpts did not elicit autobiographical memories. Rather, participants may have been focused on the psychophysical properties (e.g., dynamics, tempo, timbre) or acoustical properties of the music, and may also have been trying to assimilate the unfamiliar music into genres familiar to them. For instance, one participant mentioned they tried comparing the non-autobiographical musical excerpts to the beat of Soca music (a Cuban music style). In this case, the participant may have been trying to assimilate the unfamiliar musical excerpts into their known music schemas.

This study was part of a larger clinical research project that documented the brain connectivity of older adults as they listened to autobiographical and non-autobiographical music. The integration of qualitative and quantitative information allowed us to create a nuanced understanding of music-evoked responses in older adults. Nevertheless, this study presented some limitations. First, a sample of 18 participants was considered adequate in an exploratory study that relied on both thematic analysis (Braun & Clark, 2006) and statistical procedures, such as one-sample and paired-sample *t*-tests (De Winter, 2013). However, small sample sizes may contribute to false positives and inflated effect sizes (Ioannidis, 2005). To overcome these limitations, future studies could explore older adults' MEAMs by using larger sample sizes.

Second, we involved volunteers who were mainly White and held a high socioeconomic status. To draw more generalizable conclusions, future studies could include diverse groups of

participants. Third, participants selected their autobiographical music, but they listened to the same non-autobiographical excerpt, which they rated as largely neutral or unpleasant. Future studies with larger sample sizes could include different non-autobiographical stimuli, such as pieces that participants find pleasant. Researchers could then better explore differences among responses that are triggered by autobiographical music and a larger pool of non-autobiographical excerpts.

Despite these limitations, our findings can have several implications for age-related cognitive decline and memory impairments. As documented in this study, autobiographical music can induce memories that pertain to one's past experiences and particularly, periods of life. When older adults recall significant past experiences, they are provided the opportunity to experience a sense of gratitude and to process renewed or new meaning in their lives. Moreover, sharing significant life events with others can also help decrease feelings of loneliness and isolation (El Haj et al., 2012). And because MEAMs tend to evoke positive emotional states, they can serve as a resource for mood regulation in daily life or perhaps during challenging times, potentially reducing symptoms of depression and anxiety commonly associated with aging (Fang et al., 2017).

As MEAMs stimulate long-term memory mechanisms, they can effectively be used in music therapy interventions among aging adults. Interventions built on resilient responses to stimuli that evoke episodic memories are needed and valuable given the present-day increase in number of older adults (Caplan & Rabe, 2023) and their related cognitive declines (Whitson et al., 2018). Further, such interventions may serve as an early intervention treatment for those with greater memory and cognitive deficits such as those with mild cognitive impairment or Alzheimer's disease. Given the growing number of older adults aged over 60 years that are diagnosed with dementia (Alzheimer's Association, 2024), such interventions are greatly needed.

Finally, in this study, research findings showed that non-autobiographical music did not trigger memories of past experiences. These findings confirmed that clinicians should consider client musical interests in planning music therapy sessions. When music therapists aim to stimulate cognitive activity, particularly memory, in aging adults or adults with clinically diagnosed memory impairments, individual client's music "histories" may provide the best memory catalyst. Although this study provided new insights into the cognitive and emotional content of MEAMs among older adults, clinical research should further investigate MEAMs as a non-pharmacological treatment for age-related cognitive decline and for those with clinically diagnosed memory disorders. Future research can investigate changes and improvements that occur in neural connectivity, cognitive-psychological testing, and activities of daily living when participants listen to autobiographical music. The duration and frequency of music therapy facilitated autobiographical music listening for memory enhancement should also be investigated.

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Supplemental material

Supplemental material for this article is available online.

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