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On the role of familiarity and developmental exposure in music-evoked autobiographical memories

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ABSTRACT

Music-evoked autobiographical memories (MEAMs) are typically elicited by music that listeners have heard before. While studies that have directly manipulated music familiarity show that familiar music evokes more MEAMs than music listeners have not heard before, music that is unfamiliar to the listener can also sporadically cue autobiographical memory. Here we examined whether music that sounds familiar even without previous exposure can produce spontaneous MEAMs. Cognitively healthy older adults ($N = 75$, ages 65–80 years) listened to music clips that were chosen by researchers to be either familiar or unfamiliar (i.e., varying by prior exposure). Participants then disclosed whether the clip elicited a MEAM and later provided self-reported familiarity ratings for each. Self-reported familiarity was positively associated with the occurrence of MEAMs in response to familiar, but not the unfamiliar, music. The likelihood of reporting MEAMs for music released during youth (i.e., the "reminiscence bump") relative to young adulthood (20–25 years) included both music released during participants' adolescence (14–18 years) and middle childhood (5–9 years) once self-reported familiarity was accounted for. These developmental effects could not be accounted for by music-evoked affect. Overall, our results suggest that the phenomenon of MEAMs hinges upon both perceptions of familiarity and prior exposure.

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Music; autobiographical memory; reminiscence bump; aging

Music's ability to evoke both powerful emotions and personally salient memories is perhaps why it is one of life's greatest pleasures. Our favourite music often becomes our own personal soundtrack; not only does it narrate our day-to-day lives, but it also allows us to experience the past. In fact, spontaneous music-evoked autobiographical memories (MEAMs) occur rather often, with popular music cueing memories in 96% of younger adults (Janata et al., 2007), and a daily diary study showing they occur, on average, once a day (Jakubowski & Ghosh, 2021).

One line of research on MEAMs has compared music to other autobiographical memory cues, such as words (Jakubowski & Eerola, 2022), famous faces (Belfi et al., 2016; Belfi et al., 2022), and television (Jakubowski et al., 2021). These studies show that music elicits more vivid, detailed, and emotional memories compared to these cues (Belfi et al., 2016, 2022; Jakubowski et al., 2021). However, music only appears to be more effective at cueing autobiographical memories when it is familiar (Bloom et al., 2023; Jakubowski & Francini, 2023). A number of studies have identified positive associations between music familiarity and occurrence of MEAMs (Jakubowski et al., 2020; Janata et al., 2007; Krumhansl & Zupnick, 2013). Only two, however, have directly manipulated music familiarity by exposing participants to music they had likely heard (the "familiar" music condition) or not heard before (the "unfamiliar" music condition; Bloom et al., 2023; Jakubowski & Francini, 2023). In line with previous correlational results, both studies show that familiar music evokes more MEAMs than unfamiliar music. These results underscore the importance prior exposure plays in music's relationship with memory.

At the same time, music to which the participant has not been exposed before occasionally elicits MEAMs (Bloom et al., 2023; Jakubowski & Eerola, 2022; Janata

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et al., 2007). This raises the possibility that prior exposure might not be not necessary to evoke MEAMs. A feeling of familiarity with music can also be established via knowledge of common patterns in music, such as stylistic regularities (i.e., schematic knowledge; Vuust et al., 2022), that can be generalised to unfamiliar music. Thus, even music to which an individual has never been exposed might elicit MEAMs by evoking memories associated with stylistically (or otherwise) similar music that has truly been heard before (i.e., a form of context-dependent recall; Alonso et al., 2016; Ferreri et al., 2014; Smith, 1985). Manipulating prior exposure while also capturing participant reports of familiarity can therefore offer insight into how music without prior exposure evokes MEAMs.

This approach may also shed light on candidate processes that support the "reminiscence bump" effect. In the realm of music, this describes adults' increased amount of music-related memories (including MEAMs) associated with popular music from earlier in development (typically peaking in adolescence; Jakubowski et al., 2020; Krumhansl, 2017; Schulkind et al., 1999). Most studies calculate "song-specific age" of popular music cues to characterise this effect. This is a measure of how old participants were when each popular music cue was popularised (year of song's appearance on Billboard charts minus participants' birth year; Jakubowski et al., 2020; Krumhansl, 2017; Platz et al., 2015). Ongoing developmental processes during this time window, such as age-related improvements in episodic memory recall (Ghetti & Angelini, 2008; Willoughby et al., 2012), may account for greater memories associated with this music. However, adults also report being most familiar with popular music from their reminiscence bump time period (Jakubowski et al., 2020). This suggests that using song-specific age of popular music cues may not be effective at identifying music cues adults are actually familiar with outside of that from adolescence. The music-related reminiscence bump effect may then be attributable simply to differences in familiarity with popular music from across the lifespan. The current approach is thus limited in evaluating potential developmental processes that could give rise to the increased amount of MEAMs elicited by music from this time period. We examine these limitations by accounting for differences in participant-reported familiarity across developmental periods of release for music. This allowed us to test whether confounds in familiarity with popular music cues across the lifespan impacts the temporal location of the music-related reminiscence bump effect.

The present study

We conducted a preregistered (https://osf.io/tz5ck/) secondary analyses of data from a study investigating the effect of familiar vs. unfamiliar music on deliberate recall (i.e., using specific prompts) of autobiographical memories in cognitively healthy older adults (Bloom et al., 2023). Only one other study has directly manipulated music familiarity to investigate the association between familiarity and MEAMs to our knowledge (Jakubowski & Francini, 2023). In Bloom et al. (2023), participants self-reported familiarity with music that was selected to be either familiar or unfamiliar, along with whether they experienced a MEAM. Here, we examine these self-reported familiarity ratings (i.e., familiarity ratings for each music clip) as a potential mechanism supporting participants' reports of MEAMs elicited by unfamiliar music in this study. We hypothesised that: (1) self-reported familiarity would be positively associated with reports of MEAMs across familiar and unfamiliar music conditions and (2) within the familiar music condition, participants would report the most MEAMs in response to music from their mid-to-late adolescence. Last, in exploratory analyses, we examined whether such music-related reminiscence bumps were explained by age-related changes in self-reported familiarity or affect.

Methods

Participants

One-hundred twelve participants (Age_{mean} = 70-years-old, range: 65–79 years, SD = 3.43) were recruited for a previous study (Bloom et al., 2023), which examined the effect of music on deliberate memory retrieval in cognitively healthy older adults. Fourteen participants declined consent and an additional 3 declined participation after consenting. An additional 20 participants were excluded based on a priori exclusion criteria (see "Pre-screen Call" and Supplementary Materials for a table of exclusion reasons and demographic information). This resulted in a total of 75 participants included in these analyses. This sample size was chosen based on time and cost of participation. Simulated power analyses showed this was well-powered to detect an interaction effect of familiar over unfamiliar music exposure on deliberate memory recall, which was of interest to the previous study (see Supplemental Materials of Bloom et al., 2023 for further information on these power analyses). Participants were recruited through electronic and paper flyers targeted to retirement communities, social media, institutional participant contact lists, and word-of-mouth. Participants included in these analyses met our inclusion criteria, determined via a pre-screening video call. Because of the COVID-19 pandemic, the pre-screen call and following experimental sessions occurred over the videoconferencing software Zoom.

Pre-screen call

Participants met with a single experimenter over Zoom to determine eligibility in the study. The following criteria must have been met for a participant to be included: (1) fluency in English, (2) no reported neurological conditions,

(3) no hearing impairments that would prevent participants from hearing music over Zoom, (4) access to a computer, reliable internet access, and a quiet space to conduct video calls, (5) familiarity with musical artists that are or have been popular in the US, (6) an adequate amount of episodic memories to be probed in later experimental sessions, (7) no cognitive impairment, and (8) consent to three 60- to 90-minute experimental sessions. Two participants were excluded for reporting neurological conditions and one participant was excluded for not having access to a quiet space to complete the study. An additional 12 participants were excluded due to lack of familiarity with musical artists popular in the US and five other participants were excluded for not reporting enough episodic memories to recall in the experimental sessions.

At the onset of the pre-screen call, participants self-reported their fluency in English, known neurological conditions, hearing impairments, and access to a computer, quiet space, and internet access (inclusion criteria #1–4). Participants were then read a list of musical artists, drawn from a set of 90 unique artists who had multiple popular songs in the US from 1946–1983 (see "Stimuli"). The specific lists of artists varied by participant age, and comprised of those with the most popular songs in our music database (as operationalised by year-end "rank" on the Billboard charts) during participants' middle childhood (ages 5–9 years), mid-to-late adolescence (ages 14–18 years), and young adulthood (ages 20–25 years). Each list of 90 unique artists contained 30 unique artists per developmental time period. Participants were asked to rate how much they were exposed to each artist's music before the age of 25 on a Likert-type scale from 0 ("never heard of [this artist]") to 5 ("exposed to [this artist's music] a lot"). This process continued until participants reported a familiarity rating of three or higher for five artists per developmental period. At minimum, participants rated sixty artists (twenty artists per developmental period), after which this portion of the call concluded if they had met the five familiar artists per developmental period threshold. If they had not met this cutoff for any developmental period after rating sixty artists, participants were read ten additional artists specifically targeted at whichever developmental period had yet to reach this threshold. Participants were subsequently excluded from the study if this threshold was not met for any of these three developmental time periods after exhausting their age-specific list (inclusion criterion #5).

After reporting artist-level familiarity ratings, participants were then probed for potential episodic memories to be used in the recall portion of later experimental sessions. Participants were read a list of pre-selected memory prompts which described events participants may have experienced during each of the three developmental time periods (e.g., middle childhood: "A visit from the tooth fairy"; young adulthood: "Your college graduation"). This list contained 50 memory prompts per developmental time period, and participants were excluded if they did not report having a memory associated with at least 15 of these prompts for each time period (inclusion criteria #6). It is important to note that this exclusion criteria was not based on reports of spontaneously evoked MEAMs (and rather music-independent reports of experiencing specific memories). More information on this episodic memory selection can be found in Bloom et al. (2023). These episodic memories were not a focus of the current paper because here we only examined spontaneously evoked (and not deliberately probed) memories.

The pre-screen phone call concluded with the administration of the Telephone Montreal Cognitive Assessment (T-MoCA; Nasreddine et al., 2005; Pendlebury et al., 2013). This is a measure of cognitive health adapted for phone calls. If participants did not score above 16/22 on this test, they were consequently excluded from the study (inclusion criterion #7). While the standard cutoff for the MoCA is 87% for healthy cognition, pilot participants who scored as low as 70% correct did not struggle to understand the instructions or complete the experiment. As the T-MoCA is the same as the MoCA without the visual items, we chose the 16/22 cutoff to match this 70% threshold. Participants were asked to provide consent to take part in three experimental sessions (inclusion criterion #8) if they met inclusion criteria 1–7. These sessions were scheduled at least a week following the pre-screen call, with at least one week in between sessions.

Stimuli

To maximise prior exposure with the familiar music stimuli, we drew songs from the US Billboard Year-End Top 100 charts from 1959–1983. This yielded an average of 98 unique songs per year in this range, as some songs appeared on two consecutive Year-End Top 100 charts. In these cases, songs were assigned to the year in which they first appeared on the charts. To add songs to our database that were released before the establishment of this chart, we drew from other Billboard charts. For 1946–1958, we used Billboard's top disk-jockey plays, record-sales, and juke-box hits charts. We also considered songs in the weekly top ten of the Cash Box Disc-Hits lists and lists compiled by musicologist Joel Whitburn, specifically for songs from 1946–1955 (Whitburn, 2006). For consistency in popularity rating across charts and time periods, the number of weeks that songs appeared on charts that were not Billboard were translated into comparable "ranks" as in the Billboard charts. This approach resulted in, on average, 54 songs per year for 1946–1958. In total, there were 3,191 songs in the familiar music database. Using participants' current age, we drew the names of artists that had multiple songs in our database during the years participants were in our targeted age ranges (childhood, adolescence, young adulthood) to generate the list of artists provided to participants during their

pre-screen call. As multiple chart entries indicate a high degree of popularity of these artists, this approach allowed us to identify artists that participants were most likely familiar with.

For music to be used in the unfamiliar music condition, we compiled an unfamiliar music database, which included 300 songs that were released after 2000, did not appear on any Billboard charts, and had less than 500,000 streams on Spotify. While older adults are likely unfamiliar with popular songs within this window (Jakubowski et al., 2020), it is possible that they are nonetheless incidentally exposed to this music (e.g., over the radio or out shopping). We thus anticipated that participants would be even less familiar with songs that were not popular during this time period and that the likelihood of incidental exposure to this music was considerably lower. We originally planned to select music for this condition from artists participants did not report familiarity with and had songs towards the bottom of the Billboard Year-End charts. However, pilot data indicated that participants reported previous exposure to this music. To minimise confounds based on acoustics of familiar vs. unfamiliar music, we selected songs that were stylistically similar to our familiar music database as described below (our entire music database is available at https://osf.io/kjnwd/). This design uniquely allowed for the exploration of self-reported familiarity with stylistic similarities of music that was likely to have not been heard before by participants.

Music selection for experimental sessions

Using the familiarity ratings of artists from the pre-screen call, a list of 15 familiar music clips was selected for each participant. The highest ranking in our database by each of the top five rated artists per developmental period (childhood, adolescence, young adulthood) was selected for the familiar music clips for each participant. Only one song per artist was selected per time period. This meant three songs from the same artist, at max, were played during the familiar music condition. More than one song per artist in a session occurred only if an artist had popular songs across two developmental time windows and were rated as one of the top five most familiar artists for more than one time period. We used ratings of artist (and not song) familiarity to generate these playlists to avoid pre-exposing participants to song titles before our experimental sessions. Such exposure might trigger MEAMs, which we hoped to evoke for the first time in our sessions rather than the pre-screen call.

Music for the unfamiliar music condition was also selected on a participant-specific basis. Each of the 15 selected familiar clips were matched with 15 clips from our unfamiliar music database based on acoustic features (valence, tempo, loudness, danceability, energy, acousticness; see https://developer.spotify.com/documentation/web-api/reference/getaudio-features) and experimenter-rated genre. This matching process was designed to maximise the similarity between the familiar and unfamiliar music clips. For each participant, no acoustic feature differed across their selected familiar and unfamiliar music clips (pairwise t-tests for each participant $p > 0.05$ across all six features). This process further ensured that the unfamiliar music clips would sound similar to the familiar music clips and thus be likely to be perceived as familiar.

Procedure

This study had a within-participants design. Each participant was exposed to two experimental conditions (familiar and unfamiliar music) and a control condition (non-music clips, such as news broadcasts and traffic reports). The order of these sessions was counterbalanced across participants. Because the focus of the current paper is music-evoked autobiographical memories, the current analyses only used data from the two music conditions. In the familiar music condition, there was an additional within-participants manipulation of the timing of developmental exposure to these clips. Each familiar music session contained three blocks of five songs from a given developmental period (middle childhood [5–9 years old], mid-to-late adolescence [14–18 years old], and young adulthood [20–25 years old]; block order counterbalanced across participants).

On each trial of the two music sessions, participants first listened to a 30-second clip of the pre-selected music (unfamiliar or familiar, depending on the condition). They were then asked to self-report their music-evoked affect ("How did the clip you just heard make you feel?") in response to the clip using a Likert-type scale from 1 ("extremely negative") to 7 ("extremely positive"). Participants then spent four minutes completing a prompted autobiographical memory for the purposes of the primary study reported by Bloom et al. (2023). Specifically, they were asked to recall one of the events they had endorsed experiencing during the prescreen call. Participants were given up to four minutes to complete this recall task, and were probed for more details if they finished within the four minutes. Following this prompted recall, participants were asked if the clip they had heard on this trial had evoked any spontaneous memories ("Thinking back to the clip you heard right before this, did any memories come to mind spontaneously while you were listening?"), to which they responded "Yes" or "No". This served as our primary measure of interest (i.e., a MEAM). They also rated how related this spontaneously evoked memory was to the memory that had been experimentally prompted using a scale from 1 ("completely different") to 5 ("exactly the same"). This process was repeated for each selected music clip, resulting in 15 trials per experimental session (see Figure 1 for experimental design).

Self-reported familiarity and preference ratings

Participants reported familiarity with each music clip they were exposed throughout the study at the end of their final session. The primary purpose of the self-reported

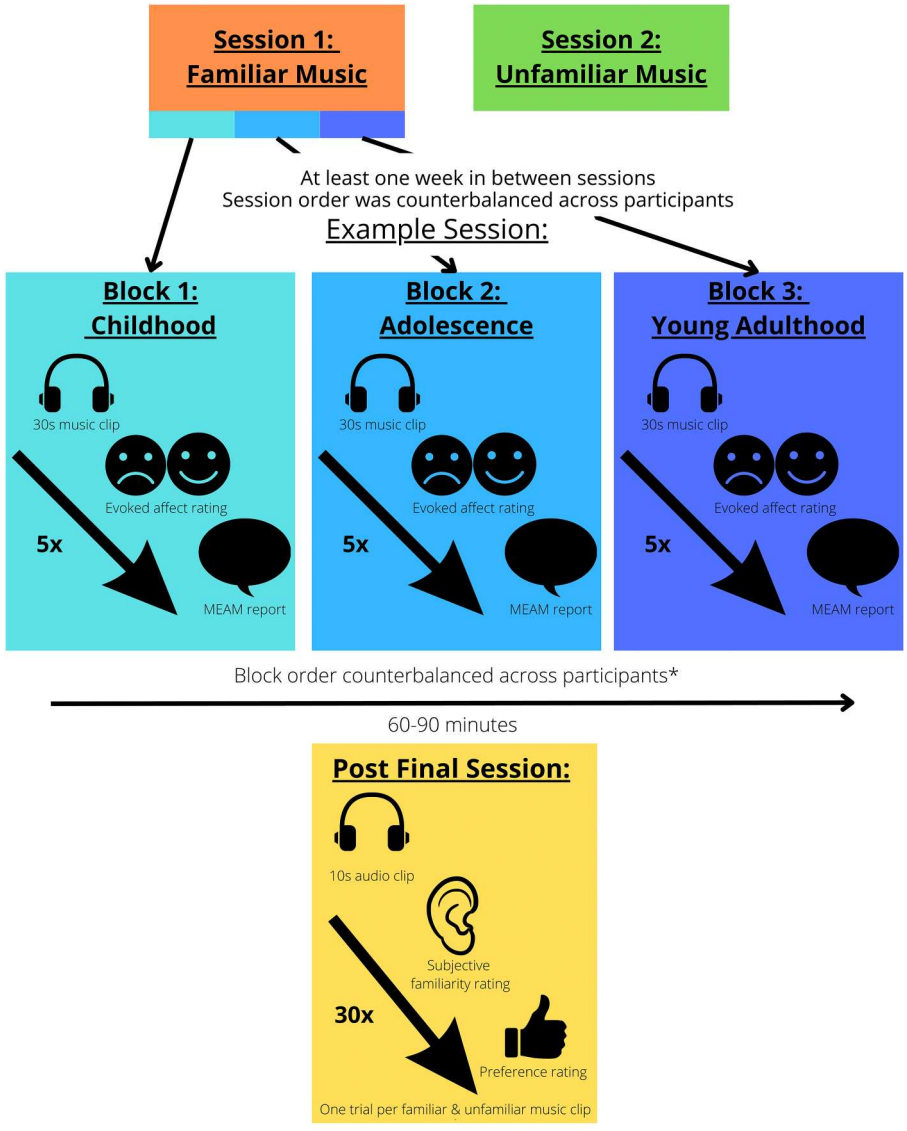

Figure 1. Experimental structure and example session, demonstrating when variables analysed in the present study were collected. In Bloom et al. (2023), participants were also asked to deliberately recall memories from pre-selected memory prompts following exposure to each music clip, and also underwent an additional third no music control session. As spontaneous music-evoked autobiographical memories were the focus of the present study, neither data from the prompted memory recall portion of the experimental sessions, nor from the control session are used in our analyses.

familiarity ratings in the original experiment was a manipulation check of our manipulation of music familiarity (Bloom et al., 2023). Thus, these ratings were at the conclusion of the experiment to prevent demand characteristics from biasing the results. Participants listened to 10 s excerpts of each clip, starting at the same as its starting position for the experimental session. After listening to each excerpt, participants self-reported familiarity for each music clip on a Likert-type scale from 1 ("not familiar at all") to 5 ("extremely familiar") and preference with a Likert-type scale from 1 ("hated the clip") to 5 ("loved the clip"). They also indicated the degree to which they were exposed to clips they rated as familiar (>1 on our scale) during the three developmental periods (with an additional option of 25 and older) using a Likert-type scale from 1 ("never listened to") to 5 ("listened to all the time"). This allowed us to determine if participants listened to a given song mainly within the developmental time period of its release or across many time periods of their lives.

Hypotheses

Our hypotheses were:

1. Reports of spontaneous music-evoked autobiographical memories would be positively associated with self-reported familiarity across familiar and unfamiliar music.

2. Music released during mid-to-late adolescence will be more likely to evoke autobiographical memories compared to music released during middle childhood or young adulthood.

Analysis plan

We used the *brms* package (Bürkner, 2019) in R to construct our preregistered models. To test hypothesis 1, we fit a Bayesian Multilevel Logistic Regression model using self-reported familiarity as a predictor of MEAMs (treated as a binary outcome), with random intercepts and slopes for each participant. Because music familiarity and preference are typically positively associated (Janata et al., 2007; Loui et al., 2010), we included self-reported familiarity and music-evoked affect in the same model. This allowed us to probe the independent contribution of self-reported familiarity to MEAMs. We also included music condition (Familiar, Unfamiliar) as an interaction term in this model. This allowed us to explore whether self-reported familiarity (and/or evoked affect) influenced MEAMs similarly across conditions. Condition was dummy-coded to treat the unfamiliar music condition as the reference level. Marginal associations of each given parameter within condition (Familiar, Unfamiliar) were obtained using the *emmeans* package (Lenth, 2021).

To replicate the "reminiscence bump" related effects for reported MEAMs, we ran a preregistered model using the developmental period of release (middle childhood, mid-to-late adolescence, and young adulthood) as a predictor variable, with random slopes and intercepts for each participant. Because the unfamiliar music condition did not include the additional developmental time period manipulation, this analysis (and all others investigating "reminiscence bump" related effects) only used trials from the familiar music condition.

To investigate the limitations of using song-specific age to understand potential developmental processes that support the music-related reminiscence bump effect, we ran a model similar to the previous preregistered one with self-reported familiarity as an additional covariate. Specifically, this model treated developmental period of release (as a categorical variable defined by song-specific ages) as a predictor variable of MEAMs while covarying for self-reported familiarity ratings. This allowed us to test, among trials rated equally on self-reported familiarity, if differences still existed as a function of developmental time period of exposure as defined by song-specific age.

Following recommendations in working with multilevel models, music-evoked affect and self-reported familiarity were mean-centered within each participant (centering within cluster, Enders & Tofighi, 2007). To ensure that condition (familiar vs. unfamiliar music) was not confounded with self-reported familiarity or music-evoked affect, these measures were also mean-centered within each condition (per participant). We inferred associations only when a parameter's 95% posterior interval (PI) did not include zero. For posterior beta estimates, all posterior intervals reported are 95% quantile intervals around the median. For posterior predictive estimates, posterior intervals represent the highest density interval (HDI) around the expected value (median) of the mean of the posterior predictive distribution. Every model used packaged-default weakly informative priors, and was run with 4 chains of 2000 sampling iterations (1000 warmup) each (see Supplementary Materials for more information on the default priors). If any $\hat{R}$ values from our models were above 1.01, which indicate convergence issues within the model (Vehtari et al., 2021), we increased the number of iterations by 1000 until the model yielded an $\hat{R}$ value less than or equal to 1.01.

Results comparing music-evoked affect and self-reported familiarity across conditions, originally reported in Bloom et al. (2023), as well as deviations from the preregistration and R syntax for all reported models, can be found in the Supplementary Materials.

Results

Familiarity and MEAMs

Bloom et al. (2023) previously reported an effect of music familiarity condition (Familiar Music, Unfamiliar Music, No-Music Control) on spontaneously evoked memories, such that participants reported more spontaneously evoked memories in the familiar music condition compared to the unfamiliar music condition and the non-music clips condition (see Figure 2(C) in Bloom et al., 2023). Here, we asked whether self-reported familiarity (i.e., familiarity ratings of music) mattered for these links between familiarity and these spontaneously evoked memories in response to the music clips (i.e., MEAMs). This revealed an interaction between self-reported familiarity and music familiarity condition on MEAMs ($\beta = -0.85$, 95% PI [−1.29, −0.45]). Specifically, the rate of MEAMs increased with greater self-reported familiarity ($\beta = 0.6$, 95% PI [0.34, 0.89]) within the familiar music condition. However, there was no association between self-reported familiarity and MEAMs in the unfamiliar music condition ($\beta = -0.25$, 95% PI [−0.58, 0.06]; see Figure 2).

Developmental period of release and MEAMs

Preregistered analyses indicated that participants were more likely to report spontaneous MEAMs in response to music released during mid-to-late adolescence compared to music released in childhood ($\beta = 0.84$, 95% PI [0.41, 1.3]) and young adulthood ($\beta = 1.06$, 95% PI [0.65, 1.5]). There was no difference in reports of MEAMs in response to music released during young adulthood compared to music released in childhood ($\beta = -0.22$, 95% PI [−0.64, 0.19]; see Figure 3(A)). However, given both the importance of self-reported familiarity to MEAMs identified

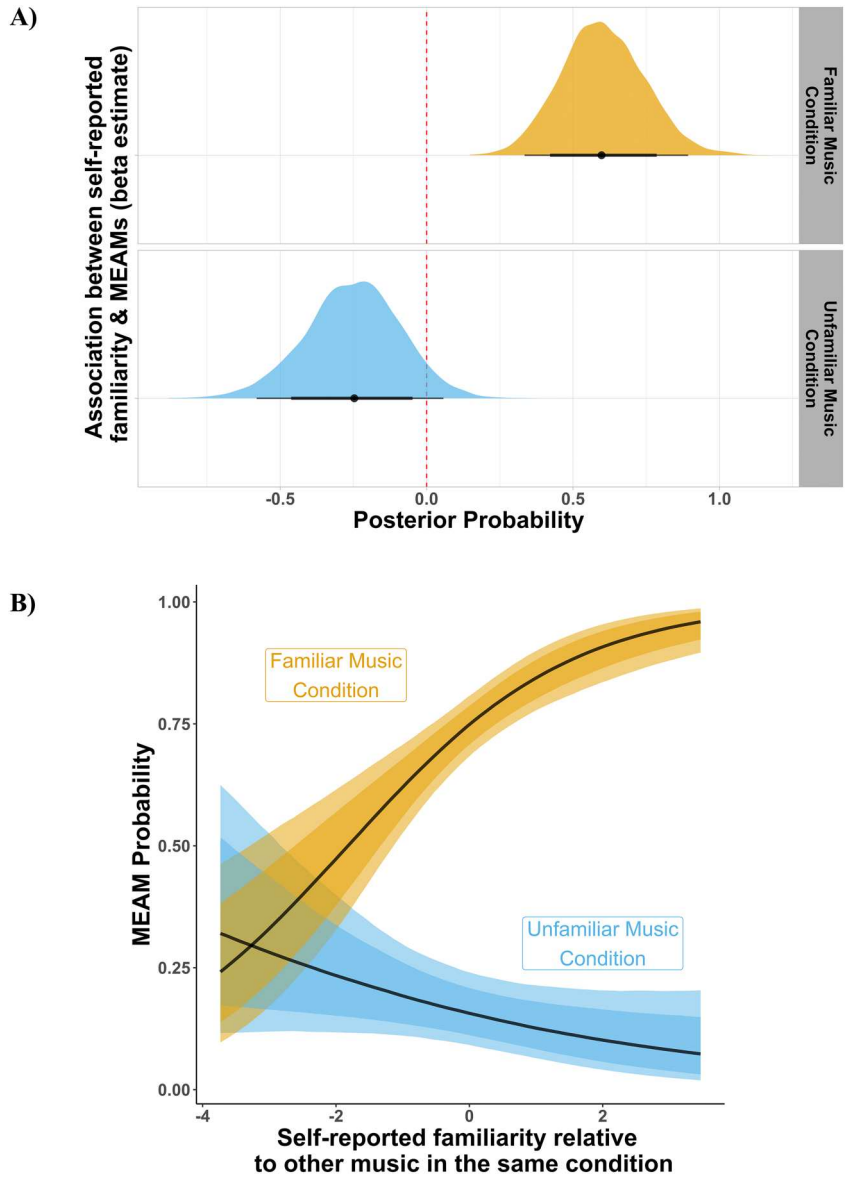

Figure 2. The association between self-reported familiarity of music and MEAMs. Association between mean-centered ratings of self-reported familiarity and reports of music-evoked autobiographical memories. (A) Posterior distributions for estimated marginal associations between mean-centered ratings of self-reported familiarity and reports of music-evoked autobiographical memories across conditions. Black points represent posterior median values, bolded horizontal lines represent the 80% posterior interval, and the remainder of that line represents the 95% PI. Posterior distributions represent the expected increase in the log odds of MEAMs with a 1-unit increase in self-reported familiarity from participants' average self-reported familiarity. (B) Model-predicted MEAM likelihood as a function of mean-centered self-reported familiarity across conditions; darker shaded regions represent 80% PI around the expected value (median) of the mean of the posterior predictive distribution, and the lighter shaded regions represent 95% PI. We note that both MEAM probability and self-reported familiarity were higher on average for clips in the familiar condition compared to the unfamiliar condition, as previously reported in Bloom et al. (2023; see Supplementary Materials). See Supplemental Table 6 for mean raw self-reported familiarity ratings by condition.

above and previous reports of differences in familiarity with popular music cues across the lifespan (Jakubowski et al., 2020), we ran an additional model controlling for self-reported familiarity. This revealed that music from childhood ($\beta = 0.68$, 95% PI [0.21, 1.16]) as well as adolescence ($\beta = 0.91$, 95% PI [0.54, 1.47]) was more likely to elicit MEAMs compared to young adulthood (see Figure 3(B)). There was no difference in MEAMs following adolescent and childhood music ($\beta = 0.31$, 95% PI [−0.14, 0.8]). This finding suggests that childhood music is as effective as adolescent music in producing MEAMs when self-reported familiarity is taken into account. This model again showed a positive association between self-reported familiarity and MEAM occurrence in the familiar condition ($\beta = 1.09$, 95% PI [0.74, 1.53]).

Music-evoked affect and MEAMs

Music-evoked affect was positively associated with reports of MEAMs elicited within the familiar music condition ($\beta =$ 0.74, 95% PI [0.56, 0.94]). In other words, more positive music-evoked affect was associated with a greater

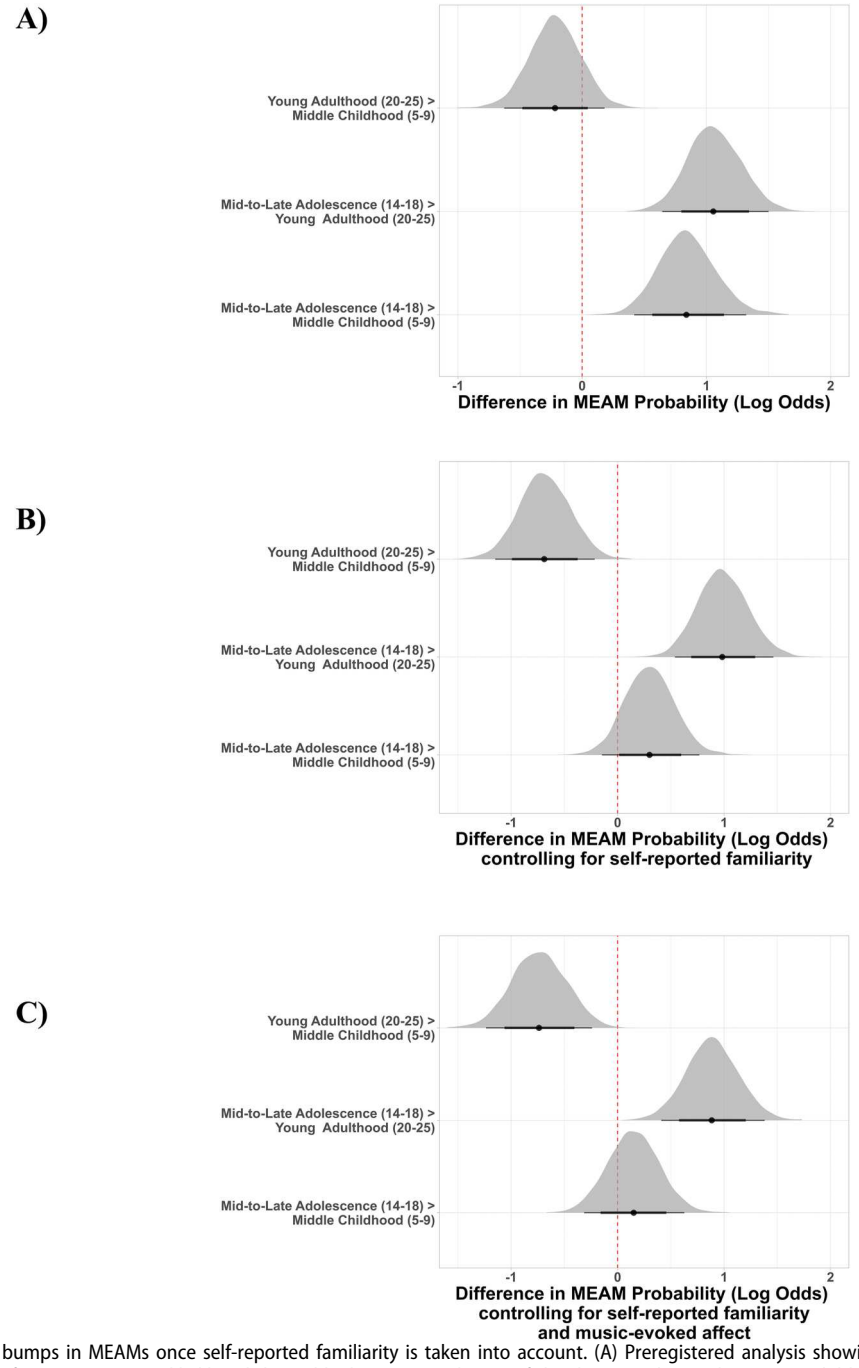

Figure 3. Reminiscence bumps in MEAMs once self-reported familiarity is taken into account. (A) Preregistered analysis showing posterior distribution contrasts representing differences in MEAM likelihood (log odds) between each pair of developmental periods (Young Adulthood > Middle Childhood, Mid-to-Late Adolescence > Young Adulthood, and Mid-to-Late Adolescence > Middle Childhood). (B) Posterior distribution contrasts representing differences in MEAM likelihood (log odds) between each pair of developmental periods (Young Adulthood > Middle Childhood, Mid-to-Late Adolescence > Young Adulthood, and Mid-to-Late Adolescence > Middle Childhood) from a model controlling for self-reported familiarity. (C) Posterior distribution contrasts representing differences in MEAM likelihood (log odds) between each pair of developmental periods (Young Adulthood > Middle Childhood, Mid-to-Late Adolescence > Young Adulthood, and Mid-to-Late Adolescence > Middle Childhood) from a model controlling for self-reported familiarity and music-evoked affect. For all panels, black points represent the difference between the expected value (median) of each pair of developmental periods, with bolded lines representing the 80% contrast posterior interval and the remainder of that line representing the 95% contrast PI.

probability of MEAMs. This relationship was consistent within the unfamiliar music condition ($\beta = 0.83$, 95% PI [0.57, 1.14]; interaction $\beta = 0.10$, 95% PI [−0.20, 0.42]; see Figure 4).

Given the positive relationship between music-evoked affect and MEAMs in the familiar music condition, we then asked whether the developmental effects reported above could be explained by differences in music-evoked affect. Participants reported more positively-valenced music-evoked affect in response to music released during adolescence compared to childhood and adulthood music (even when covarying for reported

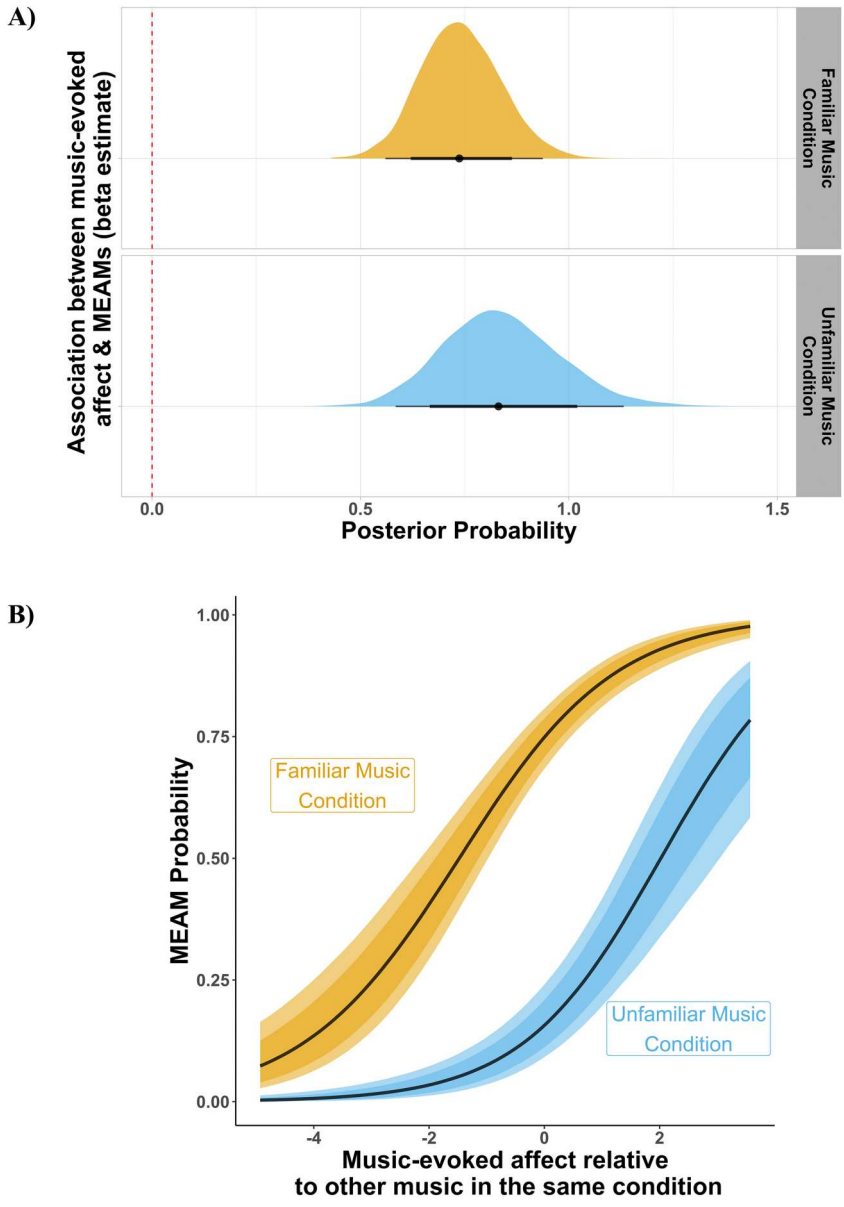

Figure 4. Association between ratings of music-evoked affect and reports of music-evoked autobiographical memories. (A) Posterior distributions for estimated marginal associations between ratings of music-evoked affect and reports of music-evoked autobiographical memories across conditions. Black points represent posterior median values, bolded horizontal lines represent the 80% posterior interval, and the remainder of that line represents the 95% posterior interval. Posterior distributions represent the expected linear increase in log odds of MEAMs with a 1-unit increase in music-evoked affect ratings from participants' average rating relative to other music in the same condition. (B) Model-predicted MEAM likelihood as a function of mean-centered music-evoked affect rating across conditions; darker shaded regions represent 80% PI around the expected value (median) of the mean of the posterior predictive distribution, and the lighter shaded regions represent 95% PI. We note that both MEAM probability and music-evoked affect ratings were higher on average for clips in the familiar condition compared to the unfamiliar condition, as previously reported in Bloom et al. (2023; see Supplement). See Supplemental Table 6 for mean raw music-evoked affect ratings by condition.

familiarity, see Supplemental Figure 8). We thus ran a post-hoc analysis to explore whether the identified MEAM-related reminiscence bump effect could be explained by these differences. This model also again showed a positive relationship between MEAM occurrence and self-reported familiarity ($\beta = 0.76$, 95% PI [0.41, 1.18]), as well as MEAM occurrence and music-evoked affect ($\beta = 0.79$, 95% PI [0.58, 1.02]). Music from childhood ($\beta = 0.74$, 95% PI [0.24, 1.24]) and adolescence ($\beta = 0.88$, 95% PI [0.44, 1.38]) was still more likely to elicit MEAMs compared to young adulthood (see Figure 3(B)). There was again no difference in MEAMs following adolescent and childhood music ($\beta =$ 0.31, 95% PI [−0.14, 0.8]; see Figure 3(C)). This suggests that the identified reminiscence-bump effects are not explained by differences in music-evoked affect.

Discussion

Past studies examining music-evoked autobiographical memories (MEAMs) have done so by either examining

correlations between participant music familiarity and reports of MEAMs or through manipulating music familiarity. Combining these approaches both sheds light on how unfamiliar music may evoke MEAMs and suggests a broader developmental window within which the music-related reminiscence bump occurs. The present study offers insight into MEAMs by illustrating that self-reported familiarity is only associated with MEAMs for music that listeners had likely heard before. As hypothesised, we replicate previous work in finding that older adults reported the most MEAMs in response to music released during their mid-to-late adolescence compared to childhood or young adulthood music (Jakubowski et al., 2020; Krumhansl, 2017). However, our results also show that music from childhood is also more likely to result in MEAMs than that from young adulthood once self-reported familiarity was taken into account. Finally, though music-evoked affect was positively associated with the occurrence of MEAMs across conditions, it did not explain differences in MEAM occurrence across developmental periods. Our results suggest that the experience of MEAMs is supported by prior exposure to music and that unfamiliar music may access autobiographical memories without perceptions of familiarity with such music.

Self-reported familiarity, prior exposure, & MEAM elicitation

We found that self-reported familiarity was related to MEAM likelihood following exposure to familiar, but not unfamiliar, music. This relationship might exist because of a broader context-induced retrieval process (i.e., context-dependent memory; Smith & Vela, 2001). In other words, familiar music may facilitate easier recall of information encoded during music listening upon subsequent exposure (Alonso et al., 2016; Ferreri et al., 2014; Smith, 1985). This account would suggest that unfamiliar music does not evoke memories in a similar manner because no previous experiences are bound to this music. Consistent with recent work showing that greater lifetime exposure to word cues leads to quicker memory recall (Gurguryan et al., 2024), this relationship in the familiar music condition likely represents a boost in rehearsal, consolidation, and/or retrieval of memories associated with music individuals are more frequently exposed to. This replicates previous research illustrating a positive relationship between cue familiarity and spontaneous autobiographical memory retrieval using spaces (Robin et al., 2019; Robin & Moscovitch, 2017), words (Harris & O'Connor, 2023; Uzer & Brown, 2017) and music (Jakubowski & Francini, 2023).

Music is informative in understanding the relationship between cue familiarity and spontaneous memory retrieval because it often employs frequently used patterns (Vuust et al., 2022). While not solely unique to music, this frequent usage of common patterns allows listeners to acquire familiarity with novel music without previous exposure. We found that unfamiliar music that is merely perceived as familiar may not spontaneously cue autobiographical memory, with the caveat that a considerable amount of the unfamiliar music cues were not perceived as familiar in the present study. We speculate that such perceived familiarity may not boost a cue's ability to spontaneously elicit autobiographical memory, regardless of modality, though future work in other domains (e.g., visual, spatial cues) is needed to test this.

Both Jakubowski and Eerola (2022) and Bloom et al. (2023) found that unfamiliar music consistently elicited less spontaneous autobiographical memories than other non-musical auditory cues, such as words and non-musical sounds. Indeed, there was a relatively low rate of MEAMs elicited by music in the unfamiliar music condition in the present study (28.77% compared to 68.65% of trials in the familiar music condition, see Supplemental Table 6). Spontaneous autobiographical memories (e.g., without cues) occur frequently in daily life as a result of mind-wandering or rumination (Berntsen, 2021; Rasmussen & Berntsen, 2011). Thus, it is possible that the reported occurrences of spontaneous autobiographical memory retrieval represent the base rate of spontaneous memory retrieval in everyday life, instead of being evoked by the unfamiliar music cues.

Participants reported more positively valenced emotions in response to unfamiliar music that they perceived as familiar (see Supplemental Figure 6). As listeners can rapidly learn to generalise and form preferences for structural and acoustic statistical regularities from musical exposure (Loui et al., 2010), it is possible that participants felt more positive after listening to unfamiliar music that was stylistically similar to music to which they have been exposed. This interpretation would indicate that participants were, in fact, sensitive to self-reported familiarity of the unfamiliar music. Alternatively, participants may have rated unfamiliar clips that made them feel more positive as more familiar. Nonetheless, the inconsistent relationship between MEAMs and self-reported familiarity across conditions may suggest that music with no prior exposure evokes MEAMs through different means than music with prior exposure. Another possibility is that unfamiliar music elicits memories via narrative engagement, a process by which listeners imagine narratives elicited by music (Margulis et al., 2022; McAuley et al., 2021). Potentially, these narratives themselves act as a memory cue: A narrative imagined while listening to music might resemble listeners' past experiences, and consequently facilitate retrieval of these experiences (Margulis & Jakubowski, 2024).

Developmental timing of music exposure on evoked memory

When we examined MEAMs in response to familiar music, we found that participants reported most MEAMs in response to music released during their adolescence vs.

childhood or young adulthood. This is consistent with past findings which show reports of MEAMs peaking in response to songs released during listeners' teenage years (Jakubowski et al., 2020; Krumhansl, 2017). When accounting for self-reported familiarity, however, there was no difference in MEAM occurrence between childhood and adolescent music. This suggests that differences in MEAM likelihood between music released during childhood vs. adolescence may be partly driven by the fact that participants were less exposed to the popular music released during their childhood, instead of the music they were exposed to (to an equal degree) during childhood being less likely to evoke MEAMs (consistent with studies showing increased familiarity for music from adolescence; Jakubowski et al., 2020).

Beyond the context of music-related memories, the reminiscence bump effect more generally describes the tendency of adults to recall the most autobiographical memories from when they were between the ages of 10–30 years (Koppel & Berntsen, 2015; Rubin & Schulkind, 1997; Rubin et al., 1986). It is thus possible that familiar childhood music cued memories from the reminiscence bump time period (e.g., adolescence or young adulthood). Nonetheless, our results suggest that such confounds in examining music-related reminiscence bump effects may contribute to mixed findings about timing and existence of this effect (Kopiez et al., 2021; Platz et al., 2015).

Other work has shown that the timing of the reminiscence bump is directly impacted by the type of memory cue used to elicit this effect (Koppel & Berntsen, 2015). For instance, word cues elicit a bump around 9–23 years old (Koppel & Berntsen, 2015) while olfactory cues elicit one around 0–10 years old (Rubin, 2015). This may suggest different mechanisms supporting this effect across different cues (Janssen, 2015; Koppel & Rubin, 2016; Rubin, 2015; Willander & Larson, 2006, 2008). Indeed, we found a slightly different timing of this effect in the present study. After controlling for self-reported familiarity and music-evoked affect, both childhood and adolescent music elicited a higher likelihood rate of MEAMs compared to music from young adulthood. This suggests that developmental processes, such as identity formation (Conway, 2005) or increased novel and/or important experiences during this time (Koppel & Berntsen, 2015; Pillemer, 2001), may contribute to the music-related reminiscence bump effect. One reason popular music cues are a powerful way to investigate such accounts of the music-related reminiscence bump effect is because they offer the ability to control for the earliest possible developmental timing of exposure (i.e., hearing a popular music before its release is impossible). However, such explanations cannot be certain without ensuring music exposure during these specific developmental windows or investigating MEAMs across the early lifespan.

We also replicated past findings that music from the reminiscence bump time period (namely, adolescent music) elicited the most positive music-evoked affect (participants also showed increased preference for this music, see Supplemental Figure 8 and 9; Jakubowski et al., 2020; Krumhansl, 2017; Platz et al., 2015). The similarity in trajectories across developmental exposure with regard to both MEAMs and music-evoked affect may suggest that the two are linked (that is, MEAMs may be increased by positive affect rather than reflecting developmental effects). However, differences in music-evoked affect across developmental time periods did not explain differences in MEAM occurrence across these time periods. One reason for this is that music-evoked affect reported in this paradigm may have been a consequence of experiencing MEAMs, rather than a cause (Juslin et al., 2014). Regardless, the current findings suggest a developmental effect with regard to music and memories that are independent from emotion confounds.

Music-evoked affect and spontaneous memories evoked by familiar and unfamiliar music

Relatedly, we detected a positive linear association between music-evoked affect and likelihood of MEAMs for both familiar and unfamiliar music. This finding is in line with previous reports of music mood-congruency effects only occurring with positively-valenced musical cues (Tesoriero & Rickard, 2012). Past work has suggested that manipulations of the emotional content of the cue itself – as opposed to the participants' affective state – has a stronger effect on eliciting mood-congruent memories (Simpson & Sheldon, 2020). The present study, however, suggests that such congruency effects on MEAMs evoked by unfamiliar music could extend beyond the emotional content of the cue (Sheldon & Donahue, 2017; Talamini et al., 2022) to include the affective state of the listener. Further, this effect may be exaggerated in the present cohort of older adults, as this age group typically demonstrates a "positivity effect" in which memory for an event is recalled as more positive than the original experience (for a review, see Charles & Carstensen, 2010). We are limited, however, in this interpretation because we did not ask participants about the content of spontaneously evoked memories. Previous work has also used ratings of pleasantness as a proxy measure for implicit memory of music (Müllensiefen & Halpern, 2014). If music-evoked affect in the present study is similarly measuring implicit memory, then the association between music-evoked affect and MEAMs in the unfamiliar music condition is consistent with our hypothesis that a sense of familiarity supports spontaneous music-evoked memories, even for unfamiliar music. Future work aimed at disentangling implicit memory, perceived familiarity, and affect in response to unfamiliar music will be needed to directly support this interpretation. Finally, consistent with work suggesting that autobiographical association is a mechanism by which music evokes emotion (Juslin et al., 2014), it is also

possible that the experience of a MEAM in response to unfamiliar music made participants feel more positive compared to those which did not evoke memories. Because our measure of music-evoked affect specifically asked how the music clip made participants feel, however, we believe these ratings most accurately reflect affect evoked by the music and not indirectly via associated MEAMs.

Limitations

We note several methodological limitations to the current study. The first is that we asked participants if they experienced any spontaneous memories in response to the music they had just heard but did not probe their content. It is therefore possible that participants occasionally responded that they experienced such a memory even though the retrieved content was non-autobiographical, such as semantic facts about a given singer or time period. We also note that the design of the experiment might have oriented participants' focus on deliberate memory retrieval, and consequently might not be representative of music listening habits in everyday life. As a result, it is likely that the design of the experiment, as well as the placement of this question after the autobiographical memory recall, may have led to over-reporting in the experience of MEAMs, especially in comparison to everyday listening experiences.

Conversely, it is possible that the four minutes of voluntary memory led to forgetting of whether the initial exposure to the music clips elicited a MEAM. However, the rate at which familiar and unfamiliar music cues in the present study (69% of familiar music trials and 29% of unfamiliar music trials; see Supplemental Table 6) matches the average rate which a similar manipulation elicited MEAMs (Jakubowski & Francini, 2023). This suggests biases such as over-reporting or forgetting are not present within the current study. Further, participants reported overlap between spontaneous MEAM content and deliberately recalled memory content (which we defined as scoring greater than or equal to 4 on a scale from 1 ["completely different"] to 5 ["exactly the same"]) in only about 10% of all the music condition trials (109/1099). This indicates participants were able to distinguish MEAMs from prompted memory recall. Nonetheless, because these potential biases are present across both conditions, comparisons of experienced MEAMs between familiar and unfamiliar music conditions should still be internally valid.

Another important limitation of the current study concerns the distributions of self-reported familiarity in each condition (see Supplemental Figure 1). Because the manipulation of prior exposure strongly impacted self-reported familiarity (Bloom et al., 2023), few music clips were rated high in self-reported familiarity in the unfamiliar music condition and few clips were rated low in self-reported familiarity in the familiar music condition. Though a positive association was identified between self-reported familiarity and MEAM occurrence in the familiar music condition, it is possible that we did not detect a similar association in the unfamiliar music condition due to an insufficient number of trials with high self-reported familiarity (i.e., lack of statistical power). However, variability in these ratings was consistent across conditions (SD = .84 and SD = .85 on a 1–5 scale in the familiar and unfamiliar music conditions, respectively). This suggests that comparisons of self-reported familiarity ratings across conditions are not confounded by a relative lack of variability within the unfamiliar music condition.

It is also possible that some participants were actually familiar with a handful of our unfamiliar music clips or unfamiliar with some of our familiar music clips. Indeed, participants reported being "not familiar at all" with some familiar music cues (20/1107 [1.81%] trials). This underscores the importance of verifying participant familiarity in tandem with experimenter manipulations of music familiarity. On the other hand, participants occasionally reported being extremely familiar with unfamiliar music cues (14/1105 [1.26%] trials). These instances enabled us to test the hypothesis that perceived familiarity without prior exposure may support MEAMs evoked by unfamiliar music. It is possible that these ratings may represent familiarity with the unfamiliar music cues based on past exposure (and not perceptions of familiarity). Familiarity with music may include veridical (i.e., familiarity with a specific piece of music) and schematic (i.e., familiarity with general patterns in music, such as stylistic conventions; Vuust et al., 2022). Future studies may be able to circumvent this potential limitation, while also eliciting more variability in self-reported familiarity of unfamiliar music, through presenting cues with schematic (i.e., familiar chord progressions or melodic contours) but not veridical (i.e., past exposure) familiarity. These studies could also benefit from asking separate targeted questions to assess these types of familiarity with music.

Another methodological consideration concerns the generalizability of the present study. Participants in the current study were all 65–80 years old, and the means of popular music listening as well as the mechanisms behind music-evoked memories may differ in different age groups and/or generational cohorts. However, cross-sectional comparisons of music-related reminiscence bumps indicate that young adults also report increased autobiographical salience in response to music from adolescence (Jakubowski et al., 2020). Our sample was also majority White, had a median income of $50,000–$75,000, and 91% held at least a bachelor's degree (see Supplemental Tables 3 & 4), indicating that our sample might not be representative of the general population. Finally, the generalizability of our findings is also limited by our music selection as we only used music from the Billboard charts and our unfamiliar music database (which was selected via stylistic similarity to the Billboard chart music).

Conclusion

While listeners may report that previously unheard music sounds familiar, there has been little prior work investigating perceived familiarity as a mechanism supporting autobiographical memories elicited by unfamiliar music. Similarly, though adults typically report most autobiographical memories in response to music from their teenage years, methods used to examine this phenomenon are limited in understanding potential supporting mechanisms. By simultaneously manipulating music familiarity and capturing self-reports of familiarity, the present study sheds light on mechanisms supporting MEAMs evoked by unfamiliar music. It also suggests that future investigations into the music-related reminiscence bump effect should verify the developmental timing of exposure to familiar music cues. Overall, our results suggest that self-reported familiarity with music does not reliably elicit autobiographical memory without prior exposure, suggesting separable (but potentially overlapping) mechanisms underlying MEAMs evoked by familiar and unfamiliar music.

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Data availability statement

Deidentified data is available at https://osf.io/56khe/.

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References

Alonso, I., Davachi, L., Valabrègue, R., Lambrecq, V., Dupont, S., & Samson, S. (2016). Neural correlates of binding lyrics and melodies for the encoding of new songs. *NeuroImage*, *127*, 333–345. https://doi.org/10.1016/j.neuroimage.2015.12.018

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*, 103305. https://doi.org/10.1016/j.concog.2022.103305

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

Berntsen, D. (2021). Involuntary autobiographical memories and their relation to other forms of spontaneous thoughts. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *376*(1817), 20190693. https://doi.org/10.1098/rstb.2019.0693

Bloom, P. A., Bartlett, E., Kathios, N., Algharazi, S., Siegelman, M., Shen, F., Beresford, L., DiMaggio-Potter, M. E., Singh, A., Bennett, S., Natarajan, N., Lee, H., Sajid, S., Joyce, E., Fischman, R., Hutchinson, S., Pan, S., Tottenham, N., & Aly, M. (2023). Effects of familiar music exposure on deliberate retrieval of remote episodic and semantic memories in healthy aging adults. *Memory (Hove, England)*, *31*(3), 428–456. https://doi.org/10.1080/09658211.2023.2166078

Bürkner, P.-C. (2019). *brms: Bayesian regression models using "Stan"* (2.10.0). https://CRAN.R-project.org/package=brms

Charles, S. T., & Carstensen, L. L. (2010). Social and emotional aging. *Annual Review of Psychology*, *61*(1), 383–409. https://doi.org/10.1146/annurev.psych.093008.100448

Conway, M. A. (2005). Memory and the self. *Journal of Memory and Language*, *53*(4), 594–628. https://doi.org/10.1016/j.jml.2005.08.005

Enders, C. K., & Tofighi, D. (2007). Centering predictor variables in cross-sectional multilevel models: A new look at an old issue. *Psychological Methods*, *12*(2), 121–138. https://doi.org/10.1037/1082-989X.12.2.121

Ferreri, L., Bigand, E., Perrey, S., Muthalib, M., Bard, P., & Bugaiska, A. (2014). Less effort, better results: How does music act on prefrontal cortex in older adults during verbal encoding? An fNIRS study. *Frontiers in Human Neuroscience*, *8*, 301. https://www.frontiersin.org/articles/10.3389fnhum.2014.00301

Ghetti, S., & Angelini, L. (2008). The development of recollection and familiarity in childhood and adolescence: Evidence from the dual-process signal detection model. *Child Development*, *79*(2), 339–358. https://doi.org/10.1111/j.1467-8624.2007.01129.x

Gurguryan, L., Yang, H., Köhler, S., & Sheldon, S. (2024). Lifetime familiarity cue effects for autobiographical memory. *Psychological Research*, *88*(5), 1456–1470. https://doi.org/10.1007/s00426-024-01968-3

Harris, C. B., & O'Connor, A. R. (2023). On the same wavelength: The impact of other-generated cues on the reported retrieval processes and qualities of autobiographical memories. *Journal of*

Applied Research in Memory and Cognition, *12*(1), 82–93. https://doi.org/10.1037/mac0000030

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

Jakubowski, K., & Eerola, T. (2022). Music evokes fewer but more positive autobiographical memories than emotionally matched sound and word cues. *Journal of Applied Research in Memory and Cognition*, *11*(2), 272–288. https://doi.org/10.1016/j.jarmac.2021.09.002

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*, 2059204320965058. https://doi.org/10.1177/2059204320965058

Jakubowski, K., & Francini, E. (2023). Differential effects of familiarity and emotional expression of musical cues on autobiographical memory properties. *Quarterly Journal of Experimental Psychology*, *76*(9), 2001–2016. https://doi.org/10.1177/17470218221129793

Jakubowski, K., & Ghosh, A. (2021). Music-evoked autobiographical memories in everyday life. *Psychology of Music*, *49*(3), 649–666. https://doi.org/10.1177/0305735619888803

Janata, P., Tomic, S. T., & Rakowski, S. K. (2007). Characterisation of music-evoked autobiographical memories. *Memory (Hove, England)*, *15*(8), 845–860. https://doi.org/10.1080/09658210701734593

Janssen, S. M. J. (2015). Commentary on Koppel and Berntsen: How many reminiscence bumps are there. *Journal of Applied Research in Memory and Cognition*, *4*(1), 81–83. https://doi.org/10.1016/j.jarmac.2014.12.002

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

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*, 20592043211001790. https://doi.org/10.1177/20592043211001794

Koppel, J., & Berntsen, D. (2015). The peaks of life: The differential temporal locations of the reminiscence bump across disparate cueing methods. *Journal of Applied Research in Memory and Cognition*, *4*(1), 66–80. https://doi.org/10.1016/j.jarmac.2014.11.004

Koppel, J., & Rubin, D. C. (2016). Recent advances in understanding the reminiscence bump: The importance of cues in guiding recall from autobiographical memory. *Current Directions in Psychological Science*, *25*(2), 135–140. https://doi.org/10.1177/0963721416631955

Krumhansl, C. L. (2017). Listening niches across a century of popular music. *Frontiers in Psychology*, *8*, 431. https://doi.org/10.3389/fpsyg.2017.00431

Krumhansl, C. L., & Zupnick, J. A. (2013). Cascading reminiscence bumps in popular music. *Psychological Science*, *24*(10), 2057–2068. https://doi.org/10.1177/0956797613486486

Lenth, V. R. (2021). emmeans: Estimated marginal means, aka least-squares means. R package version 1.6.3. https://CRAN.R-project.org/package=emmeans

Loui, P., Wessel, D. L., & Kam, C. L. H. (2010). Humans rapidly learn grammatical structure in a new musical scale. *Music Perception*, *27*(5), 377–388. https://doi.org/10.1525/mp.2010.27.5.377

Margulis, E. H., & Jakubowski, K. (2024). Music, memory, and imagination. *Current Directions in Psychological Science*, *33*(2), 108–113. https://doi.org/10.1177/09637214231217229

Margulis, E. H., Wong, P. C. M., Turnbull, C., Kubit, B. M., & McAuley, J. D. (2022). Narratives imagined in response to instrumental music reveal culture-bounded intersubjectivity. *Proceedings of the National Academy of Sciences*, *119*(4), e2110406119. https://doi.org/10.1073/pnas.2110406119

McAuley, J. D., Wong, P. C. M., Mamidipaka, A., Phillips, N., & Margulis, E. H. (2021). Do you hear what I hear? Perceived narrative constitutes a semantic dimension for music. *Cognition*, *212*, 104712. https://doi.org/10.1016/j.cognition.2021.104712

Müllensiefen, D., & Halpern, A. R. (2014). The role of features and context in recognition of novel melodies. *Music Perception*, *31*(5), 418–435. https://doi.org/10.1525/mp.2014.31.5.418

Nasreddine, Z. S., Phillips, N. A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., Cummings, J. L., & Chertkow, H. (2005). The Montreal cognitive assessment, MoCA: A brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society*, *53*(4), 695–699. https://doi.org/10.1111/j.1532-5415.2005.53221.x

Pendlebury, S. T., Welch, S. J. V., Cuthbertson, F. C., Mariz, J., Mehta, Z., & Rothwell, P. M. (2013). Telephone assessment of cognition after transient ischemic attack and stroke. *Stroke*, *44*(1), 227–229. https://doi.org/10.1161/STROKEAHA.112.673384

Pillemer, D. B. (2001). Momentous events and the life story. *Review of General Psychology*, *5*(2), 123–134. https://doi.org/10.1037/1089-2680.5.2.123

Platz, F., Kopiez, R., Hasselhorn, J., & Wolf, A. (2015). The impact of song-specific age and affective qualities of popular songs on music-evoked autobiographical memories (MEAMs). *Musicae Scientiae*, *19*(4), 327–349. https://doi.org/10.1177/1029864915597567

Rasmussen, A. S., & Berntsen, D. (2011). The unpredictable past: Spontaneous autobiographical memories outnumber autobiographical memories retrieved strategically. *Consciousness and Cognition*, *20*(4), 1842–1846. https://doi.org/10.1016/j.concog.2011.07.010

Robin, J., Garzon, L., & Moscovitch, M. (2019). Spontaneous memory retrieval varies based on familiarity with a spatial context. *Cognition*, *190*, 81–92. https://doi.org/10.1016/j.cognition.2019.04.018

Robin, J., & Moscovitch, M. (2017). Familiar real-world spatial cues provide memory benefits in older and younger adults. *Psychology and Aging*, *32*(3), 210–219. https://doi.org/10.1037/pag0000162

Rubin, D. C. (2015). One bump, two bumps, three bumps, four? Using retrieval cues to divide one autobiographical memory reminiscence bump into many. *Journal of Applied Research in Memory and Cognition*, *4*(1), 87–89. https://doi.org/10.1016/j.jarmac.2014.12.005

Rubin, D. C., & Schulkind, M. D. (1997). The distribution of autobiographical memories across the lifespan. *Memory & Cognition*, *25*(6), 859–866. https://doi.org/10.3758/BF03211330

Rubin, D. C., Wetzler, S. E., & Nebes, R. D. (1986). *Autobiographical memory across the lifespan* (1st ed., pp. 202–222). Cambridge University Press.

Schulkind, M. D., Hennis, L. K., & Rubin, D. C. (1999). Music, emotion, and autobiographical memory: They're playing your song. *Memory & Cognition*, *27*(6), 948–955. https://doi.org/10.3758/BF03201225

Sheldon, S., & Donahue, J. (2017). More than a feeling: Emotional cues impact the access and experience of autobiographical memories. *Memory & Cognition*, *45*(5), 731–744. https://doi.org/10.3758/s13421-017-0691-6

Simpson, S., & Sheldon, S. (2020). Testing the impact of emotional mood and cue characteristics on detailed autobiographical memory retrieval. *Emotion*, *20*(6), 965–979. https://doi.org/10.1037/emo0000603

Smith, S. M. (1985). Background music and context-dependent memory. *The American Journal of Psychology*, *98*(4), 591–603. https://doi.org/10.2307/1422512

Smith, S. M., & Vela, E. (2001). Environmental context-dependent memory: A review and meta-analysis. *Psychonomic Bulletin and Review*, *8*(2), 203–220. https://doi.org/10.3758/BF03196157`

Talamini, F., Eller, G., Vigl, J., & Zentner, M. (2022). Musical emotions affect memory for emotional pictures. *Scientific Reports*, *12*(1), 10636. https://doi.org/10.1038/s41598-022-15032-w

Tesoriero, M., & Rickard, N. S. (2012). Music-enhanced recall: An effect of mood congruence, emotion arousal or emotion function? *Musicae Scientiae*, *16*(3), 340–356. https://doi.org/10.1177/1029864912459046

Uzer, T., & Brown, N. R. (2017). The effect of cue content on retrieval from autobiographical memory. *Acta Psychologica*, *172*, 84–91. https://doi.org/10.1016/j.actpsy.2016.11.012

Vehtari, A., Gelman, A., Simpson, D., Carpenter, B., & Bürkner, P.-C. (2021). Rank-normalization, folding, and localization: An improved R̂ for assessing convergence of MCMC (with discussion). *Bayesian Analysis*, *16*(2), 667–718. https://doi.org/10.1214/20-BA1221

Vuust, P., Heggli, O. A., Friston, K. J., & Kringelbach, M. L. (2022). Music in the brain. *Nature Reviews Neuroscience*, *23*(5), 287–305. https://doi.org/10.1038/s41583-022-00578-5

Whitburn, J. (2006). *Billboard top 1000 hits of the rock era, 1955–2005*. Hal Leonard Corporation.

Willander, J., & Larsson, M. (2006). Smell your way back to childhood: Autobiographical odor memory. *Psychonomic Bulletin and Review*, *13*(2), 240–244. https://doi.org/10.3758/bf03193837

Willander, J., & Larsson, M. (2008). The mind's nose and autobiographical odor memory. *Chemosensory Perception*, *1*(3), 210–215. https://doi.org/10.1007/s12078-008-9026-0

Willoughby, K. A., Desrocher, M., Levine, B., & Rovet, J. F. (2012). Episodic and semantic autobiographical memory and everyday memory during late childhood and early adolescence. *Frontiers in Psychology*, 3. https://doi.org/10.3389/fpsyg.2012.00053