When You Heard it First: Age of Encoding.... Outline

Lifespan, Song-specific, Preference, Reward, Reminiscence Bump

Abstract (from CNS submission):  
The “reminiscence bump” describes the ability of older adults to recall a disproportionately high amount of autobiographical memories from adolescence and young adulthood compared to any other time across the lifespan. This effect holds true for music-evoked autobiographical memories: not only do older adults recall more autobiographical memories in response to music from their adolescence and young adulthood compared to music outside this time period, but they also show lifelong preferences for music from this time period. Here we explored the effect of developmental timing of music encoding on how it is represented in the brain. We collected fMRI data on older adults (n=17; ages 56-89) while they listened to both self-selected and researcher-selected musical excerpts. Whole-brain fMRI analyses across all music listening conditions revealed activation in auditory regions (superior temporal gyrus and Heschl’s Gyrus) and the Default Mode Network (medial prefrontal cortex and posterior cingulate cortex). Compared to music released during childhood (ages 0-11) or adulthood (ages 19+), music released during adolescence (ages 12-18) showed greater activation in the Default Mode Network, specifically the posterior cingulate cortex, surviving FDR cluster-size correction at the 0.05 level. These results demonstrate how stimuli encoded during adolescence differ from those outside this time period, providing neuroscientific insight into the reminiscence bump effect and the development of lifelong preferences.

Introduction

1. Behavioral evidence of impact of encoding
2. Belfi & Loui → model of music reward
3. Casey → functional connectivity model of adolescence

Materials and Methods

Participants

Participants were recruited via Craigslist.org and word of mouth at Brigham and Woman’s Hospital. Twenty-two participants met the inclusion criteria for the main study (Quinci et al., 2021), determined by a pre-screening phone call. Of these, three dropped out of the study during their scan and another was removed from data analysis due to an error in music presented during their scan. Because this secondary analysis is concerned only with participants’ first scan, we did not apply additional exclusion criteria from the main analysis regarding longitudinal effects of music-based interventions and follow-up scans. As such, participants previously excluded due to longitudinal dropout (i.e. not completing the scan after undergoing a music-based intervention) will be included in these analyses. Following, we had a total sample of 18 older adults between the ages of 56 and 89 (SAMPLE STATS)

Procedure

Pre-screening Call

Participants who demonstrated interest in our study in response to our recruitment material subsequently met with one experimenter over the phone to determine eligibility in the study. The following criteria must have been met for a participant to be included in the study: 1) were at least 50 years old, 2) had normal hearing, 3) passed MRI screening, and 4) scored a ≥ 31/41 on the Telephone Interview for Cognitive Status (TICS). Participants were excluded at this stage if they 1) changed medications within 6 weeks of screening, 2) had a history of psychotic or schizophrenic episodes, major neurological diagnosis, or other medical condition that might impair cognition, 3) had a history of chemotherapy within the past 10 years, or 4) experienced serious physical trauma or were diagnosed with a serious chronic health condition requiring medical treatment and monitoring within 3 months of screening. After establishing that participants met these requirements, they filled out an MRI pre-entry screening form and provided the researcher with the names of six pieces of music or songs they enjoy listening to. Finally, they were invited to the lab to complete a battery of neuropsychological and behavioral measures, an MRI scan, and a blood draw. More information on participants’ subsequent meeting with a music therapist and follow-up scans, which are beyond the scope of these analyses, can be found in the main analysis of this study (Quinci et al., 2021).

fMRI Task

The main music listening fMRI task was a block 24 trials, each consisting of a presentation of a unique musical clip for 20 seconds and subsequent self-reports of how familiar (on a Likert-type scale from 1 meaning “very unfamiliar” and 4 meaning “very familiar”) and how well-liked (on a Likert-type scale from 1 meaning “hate” to 4 meaning “love”) each clip was. Musical clips were presented in a randomized manner across participants. Six of the clips were self-selected by participants (and thus varied across participants), whereas the remaining 18 were researcher-selected and presented to every participant. Of these 18 researcher-selected clips, 10 were aimed to be familiar to participants while the other 8 were selected to be unfamiliar to participants.

Participants wore MR-compatible over-the-ear headphones (Cambridge Research Systems) over musician-grade silicone ear plugs during MRI data acquisition. fMRI Data Acquisition Images were acquired using a Siemens Magnetom 3T MR scanner with a 64-channel head coil at Northeastern University. For task fMRI data, continuous acquisition was used for 1440 volumes with a fast TR of 475 ms for a total acquisition time of 11.4 minutes. Forty-eight axial slices (slice thickness = 3 mm, anterior to posterior, z volume = 14.4 mm) were acquired as echo-planar imaging (EPI) functional volumes covering the whole brain (TR = 475 ms, TE = 30 ms, flip angle = 60°, FOV = 240mm, voxel size = 3 x 3 x 3 mm³). T1 images were also acquired using a MPRAGE sequence, with one T1 image acquired every 2400 ms, for a total task time of approximately 7 minutes. Sagittal slices (0.8 mm thick, anterior to posterior) were acquired covering the whole brain (TR = 2400 ms, TE = 2.55 ms, flip angle = 8°, FOV= 256, voxel size = 0.8 x 0.8 x 0.8 mm3).

Follow-up Interview

To gain further insight into when participants were first exposed to the musical stimuli heard during the fMRI task, we conducted follow-up interviews. Of the 18 participants who completed the first scan, 10 participants completed this interview. In these interviews, participants listened to both their self-selected clips, along with the 10 researcher-selected clips intended to be familiar. While listening to these clips, participants were instructed to report any autobiographical memories that were spontaneously evoked during music listening and self-report evoked emotion valence (on a Likert-type scale from 1 meaning “extremely negative” to 7 meaning “extremely positive”) and arousal (on a Likert-type scale from 1 meaning “extremely calm” to 7 meaning “extremely energized”), as well as when they first thought they had heard that clip. If they reported having a memory elicited by the clip, participants were also instructed to report how old they were in that memory.

Calculating Age of Exposure

As a proxy for the age at which participants first heard the clips they were exposed to during the fMRI task, we used song-specific age (SSA), a measure of how old the participant was when the stimuli was first released. We calculated SSA by subtracting the year in which the participant was born from the year in which the stimulus was first released. This was completed for every self-selected clip participants listened to in the scanner, along with any researcher-selected clip rated at a “4” on our familiarity scale (meaning very familiar) or those which participants could self-report the age at which they first heard the clip during the follow-up interview.

Because some participants self-selected music from before they were born (which resulted in negative SSA), we then utilized their self-report of when they first heard that musical clip from the follow-up interviews. If a negative SSA was associated with a participant who was not able to complete a follow-up interview, that trial was removed from data analysis. We then binned these stimuli according to SSA and self-report of exposure across four developmental time periods: childhood (0-11), adolescence (12-18), young adulthood (19-25), and adulthood (26-45).

Data Analysis Preprocessing

Task fMRI data were preprocessed and analyzed using SPM12 (Statistical Parametric Mapping) software and the CONN Toolbox. The following preprocessing steps were taken: functional realignment and unwarping, functional centering, functional slice time correction, functional outlier detection using the artifact detection tool, functional direct segmentation and normalization to MNI template, structural centering, structural segmentation and normalization to MNI template, and functional smoothing to an 8mm gaussian kernel. The data were then denoised with white matter and cerebrospinal fluid confound correction, and bandpass filtering to 0.008–0.09 Hz. For each participant, data were converted from 4D to 3D images, resulting in 1440 scans. Models in SPM12 and CONN were specified with an interscan interval of 0.475 seconds, a microtime resolution of 16, a microtime onset of 8, and a duration of 42.

Extracting Audio Features of Clips

To ensure the clips participants heard did not differ acoustically across time periods, we extracted music-information retrieval data from each of our 20 second clips from the MIRToolbox (Lartillot and Toiviainen, 2007) in MATLAB R.2021a. The specific features we extracted were pulse clarity, a measure of beat saliency, RMS energy, a measure of loudness, and event density, a measure of (DESCRIBE!). For all three features, used a sampling rate of 44100 Hz and an overlap of 50% for frame decomposition. For pulse clarity, we used a frame rate of (INSERT) and for RMS energy and event density, we used a frame rate. Each measurement was averaged across frames to obtain one measure for each clip of all three measures.

Univariate Whole Brain Analysis

Only data from the time while the participant was listening to the musical excerpt (as opposed to when the participant was self-reporting familiarity and liking ratings) were included in the models. At the first-level, we extracted the main effect of each developmental time period, along with each time period contrasted with both subsets of unfamiliar music, as well as music intended to be familiar, but which participants reported to be unfamiliar with (a rating of “1” on our familiarity scale). Both the main effects and contrasts were then analyzed using a one-sample t-test across all participants at the second level, corrected at the cluster and voxel FDR-corrected level of p <0.05.

Seed-Based Connectivity Analysis

Seed-based connectivity analysis was calculated with the CONN toolbox to determine functional connectivity patterns across developmental timing of exposure to musical stimuli. Seed ROIs consisted of Auditory and Reward networks defined by previous work in our lab.

Results

Univariate Whole Brain Effects of Developmental Timing of Exposure

Seed-Based Connectivity

mPFC Connectivity

NAc connectivity across lifespan

Reward Network Connectivity

Auditory Network Connectivity

ROI-ROI Connectivity