Brain networks underlying the retrieval and experience of music-evoked autobiographical memories.

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Introduction

The evocation of autobiographical memories and associated emotions by music counts among the most poignant experiences associated with music. Accordingly, excerpts of music can serve as potent retrieval cues with which to study the functional architecture of autobiographical memory. Converging evidence (Figure 1) suggests that the rostral aspect of the medial prefrontal cortex (BA10) is a region where music and autobiographical memories might be integrated. This study tested the hypothesis that experiencing autobiographically salient musical excerpts would result in increased activation in the medial prefrontal cortex.

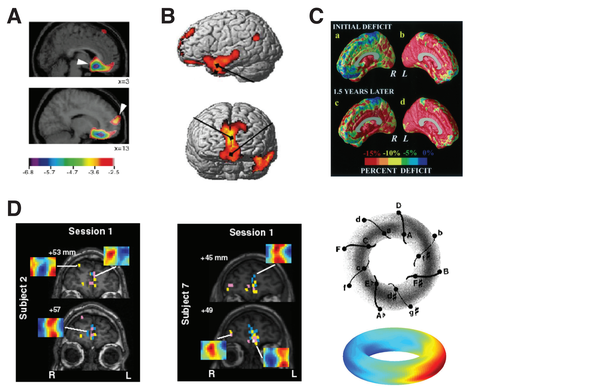

Figure 1. Prior studies provide converging evidence for the hypothesis that music, emotion and memories interact in the medial prefrontal cortex (MPFC). A) Blood & Zatorre (1999) showed that increasing consonance of melodies with harmonic accompaniment led to increased blood flow in ventral and dorsal MPFC. B) Familiarity judgments about excerpts of real music result in increased MPFC activation (Platel et al., 2003). C) MPFC is relatively spared in later stages of Alzheimer's Disease (AD; Thompson et al., 2003). Patients with advanced AD become cognitively and emotionally engaged with autobiographically salient songs (Cuddy & Duffin, 2005). D) Patterns of activity in MPFC correlate with the pattern of movement of a melody through the tonal space defined by the 24 major and minor keys (represented by the tori on the right; Janata et al., 2002).

Methods

Prescreening and memory characterization

As part of an ongoing survey and description of autobiographical memories evoked by pieces of music, subjects heard 30s excerpts that were selected at random from the Billboard Top 100 Pop and R&B charts from the years in which the subject was between 7 and 19 years of age. Following each excerpt, a subject reported whether the song was familiar and if so whether it evoked a weakly or strongly autobiographical memory or no clear memory at all. For songs identified as autobiographically salient, a more extensive set of questions was administered to probe the specific content of the evoked memory/ies. Subjects were invited to participate in the fMRI version of the experiment if >30% of the excerpts evoked an autobiographical memory.

fMRI experiment

14 subjects (12 female) were presented with 30 stimuli (selected according to the same criteria as above) across two scanning runs. Excerpts encountered by the subject in the prescreen were excluded from selection. One minute of resting-state activity was recorded prior to the 1st stimulus. Following each excerpt, subjects provided ratings (using left hand) of the affective valence (5-point scale) and arousal (5-pt scale) they experienced while listening to the excerpt, their familiarity with the song (2 pt scale), its autobiographical salience (3 pt scale), and the orientation of their attention toward the memories (5 pt scale) and music (5 pt scale). Immediately following the scanning session, subjects completed a detailed survey about their episodic memories pertaining to songs they correctly identified as having heard in the scanner and flagged as being autobiographically salient. Scanner parameters: Siemens 3T Trio, 34 slices (4 mm thick, 0 skip), TR=2.0s, in-plane resolution: 3.4x3.4 mm. Data were spatially normalized and analyzed in SPM5. See Fig. 4 for examples of subject design matrices.

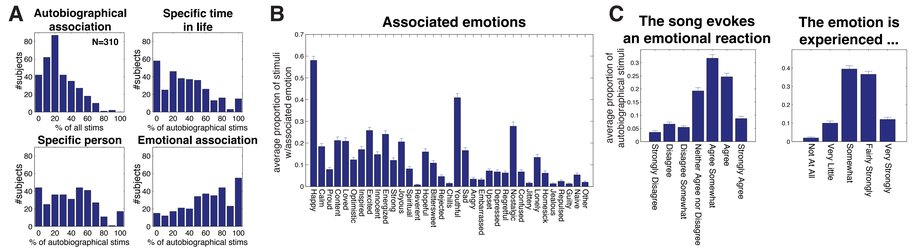

Figure 2. Characterization of memories and emotions evoked by autobiographically salient pieces of music. A) The top left panel shows the percentages of stimuli that evoked autobiographical memories across 310 subjects. The other panels show the percentages of the autobiographical stimuli that elicited memories of specific times in one's life, specific people, or which had an emotional association. Emotional associations are quite common. B) A range of emotions were associated with autobiographically salient songs. C) There was a strong tendency to agree that the specific songs evoked emotional reactions and that the emotions were experienced during that particular presentation of the song. These data indicate that such song excerpts are potent stimuli for inducing a variety of emotions.

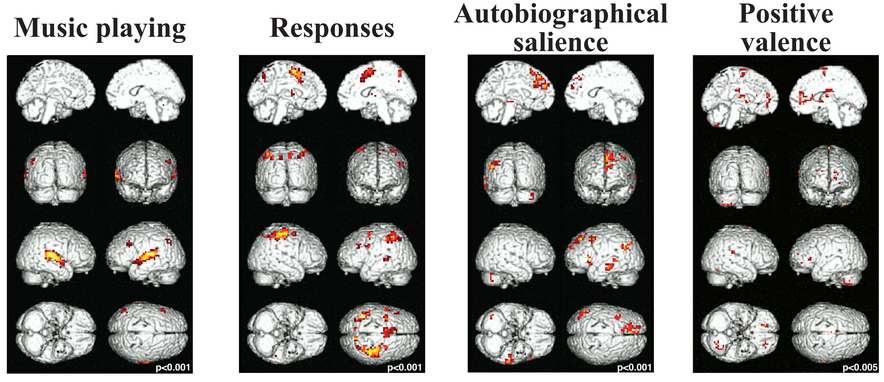

Figure 3. Group activations. Contrast images (beta-estimates) for the regressors of interest (see Fig. 4) from the 14 subject-specific analyses were entered into a group analysis. The "music playing" contrast shows regions of activation while music was heard (irrespective of autobiographical salience or emotional valence) relative to periods where responses were being made and the brief inter-trial intervals and rest periods before and after the musical excerpts. The "responses" contrast shows regions of significant activation while response cues were being processed and responses were being made regarding the person's disposition to the excerpt they just heard. The "autobiographical salience" contrast identifies region of linear activity increases across 3 levels of autobiographical salience, and the "positive valence" contrast highlights regions that increased in activity when people found the excerpt they just heard more pleasing. The activations along the medial wall in the autobiographical salience and valence contrasts support the hypothesis that regions implicated in self-referential processing would show stronger responses to autobiographically salient pieces of music.

Conclusions

A network of superior temporal, parietal, and lateral (both dorsal and ventral) prefrontal implicated in previous studies of attentive music processing is coactivated with medial prefrontal areas implicated in self-referential processing during the experience of song excerpts that evoke autobiographically salient memories. These results shed light on the interaction of brain networks for interoceptive and exteroceptive processing.

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Individual subject data

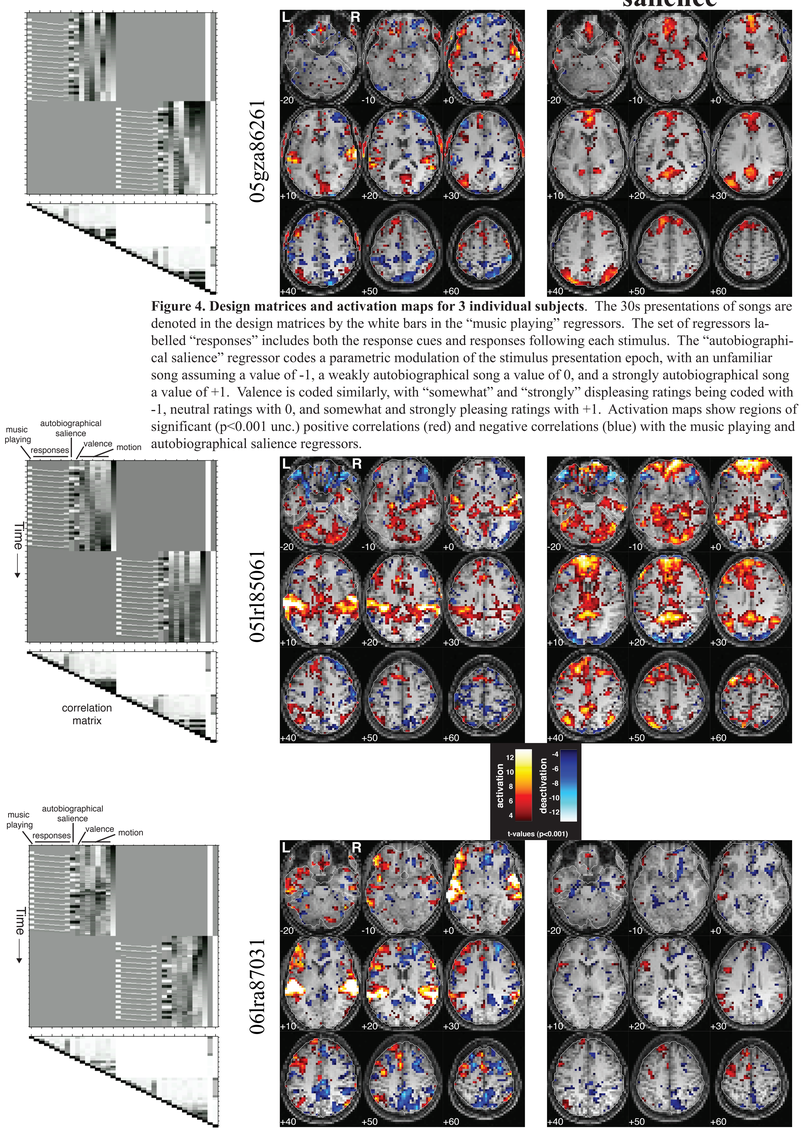

Figure 4. Design matrices and activation maps for 3 individual subjects. The 30s presentations of songs are denoted in the design matrices by the white bars in the "music playing" regressors. The set of regressors labelled "responses" includes both the response cues and responses following each stimulus. The "autobiographical salience" regressor codes a parametric modulation of the stimulus presentation epoch, with an unfamiliar song assuming a value of -1, a weakly autobiographical song a value of 0, and a strongly autobiographical song a value of +1. Valence is coded similarly, with "somewhat" and "strongly" displeasing ratings being coded with -1, neutral ratings with 0, and somewhat and strongly pleasing ratings with +1. Activation maps show regions of significant (p<0.001 unc.) positive correlations (red) and negative correlations (blue) with the music playing and autobiographical salience regressors.