Engagement of the anterior temporal lobe in strong emotional experiences with musical and non-musical stimuli.

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103.21

Introduction

Music listening can evoke strong and personally salient emotions (Juslin, 2008; Zentner, 2008; Krumhansl, 2000), autobiographical memories (Janata, 2007, 2009; Barrett, 2010), and spiritual experiences (Penman & Becker, 2009) that typically have strong affective components. The degree to which such strong experiences with music engage neural areas underlying other affective processes is not well understood. We investigated this issue in two studies using a variety musical and non-musical affective tasks, with the aim of identifying common brain areas across tasks whose activity was related to emotional experience.

Study 1: Induction and Music-Evoked Nostalgia

11 UC Davis students (8 females; age: 18-33; mean: 22.8 +/- 4.4) who had experienced at least 30% music-evoked autobiographical memories (MEAMs) in a music-evoked nostalgia validation study (Barrett, 2010) were enrolled, and completed tasks while BOLD signal was collected at 3T.

Affect Induction: Two procedures used in affect induction are the Velten procedure (Velten, 1968; Frost, 1982; Goritz, 2006) and the Schneider procedure (Schneider, 1997, 2004, 2007).

Velten Procedure: 30 ordered, self-referential statements of increasing emotional intensity.

**Schneider Procedure**: 40 photographs of actors making facial emotional expressions.

Before and after each run, participants gave separate ratings of how happy and how sad they had felt, on the following 5pt scale: Not at all, Weakly, Moderately, Strongly, Extremely.

Music-Evoked Nostalgia: Participants listened to (30) 20s songs, chosen randomly from songs on the Pop, Hip Hop, and R&B Billboard Charts when the given participant was between 7 and 19 years old (Janata, 2007; Barrett 2010). After each song, they rated the degree to which they had experienced Nostalgia, Happiness, Sadness, and Autobiographical Memories on a 5pt scale.

fMRI Analysis: SPM5 was used for standard EPI image preprocessing. EPIs were resliced into 3mm isotropic voxels, and smoothed with a 5-mm FWHM kernel. The effects of mean signal differences per run, motion, and linear drift were removed via GLM. **Spatial Independent Component Analyses** (sICA) were conducted separately on each task using the Group fMRI for ICA Toolbox (GIFT; Calhoun, 2009). GIFT estimated the number of components necessary to fully represent the data from each task (120 music listening components, 142 Velten task components, and 155 Schneider task components).

Meaningful components were identified for each task and condition by group-level analyses regressing back-reconstructed within-subject timecourses for each component on design matrices for each task. Responses after each song during the nostalgia procedure were modeled as parametric modulations of a "music playing" block regressor. Each block of each affect induction run was modeled with a separate monotonically increasing linear regressor, to model increasing mood state as increasing activation over the course of a single block. Component cluster maps for each task were generated by summing across 3D spatial maps for all meaningful components.

Results: Affect Induction
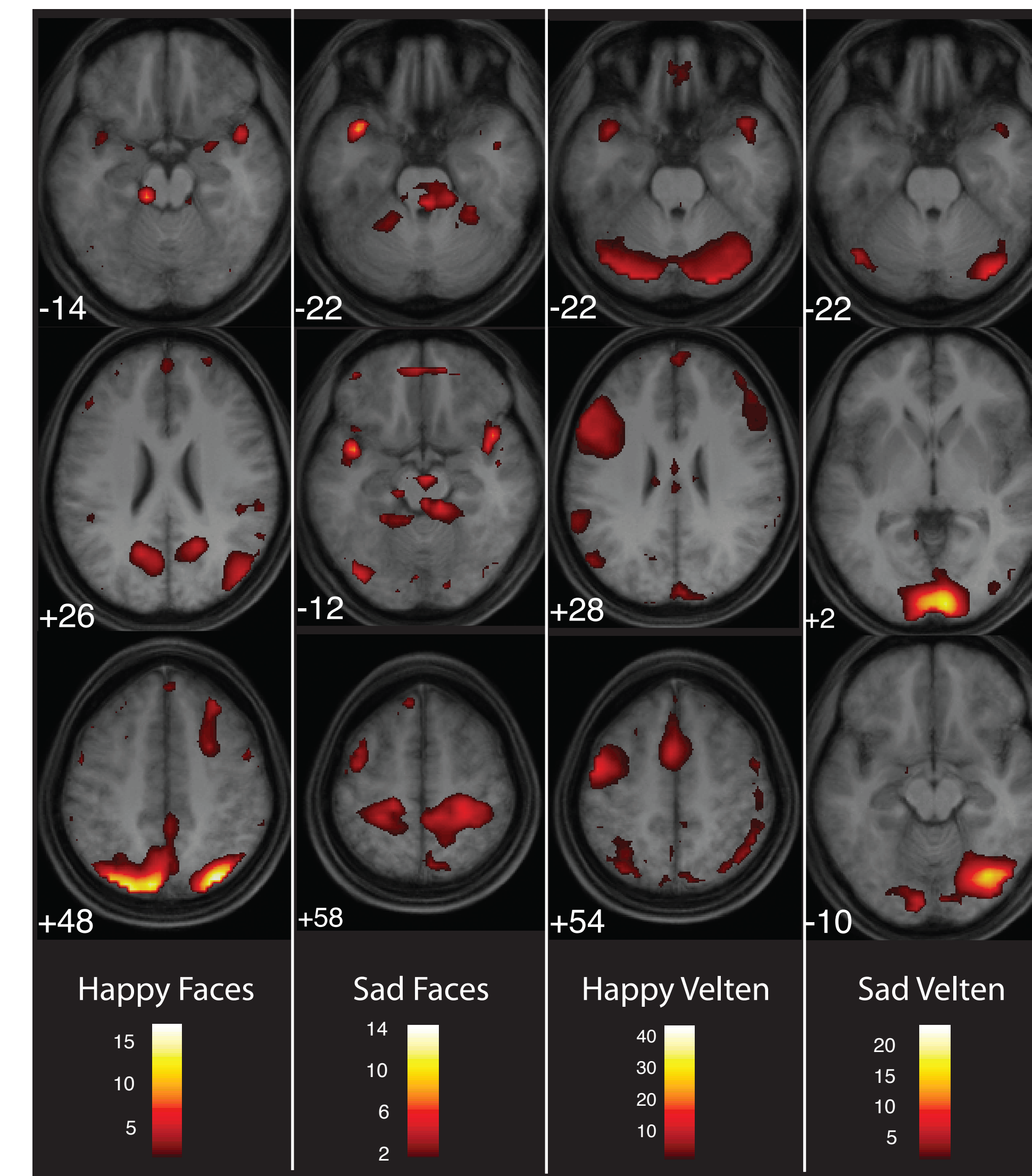
Component cluster maps for affect induction tasks. Spatial maps for meaningful components were expressed as z-score maps, thresholded at values of 2 standard deviations, and linearly combined to show those voxels active in each condition. Happy faces: 4 components; sad faces: 5 components; happy Velten: 13 components; sad Velten: 3 components.
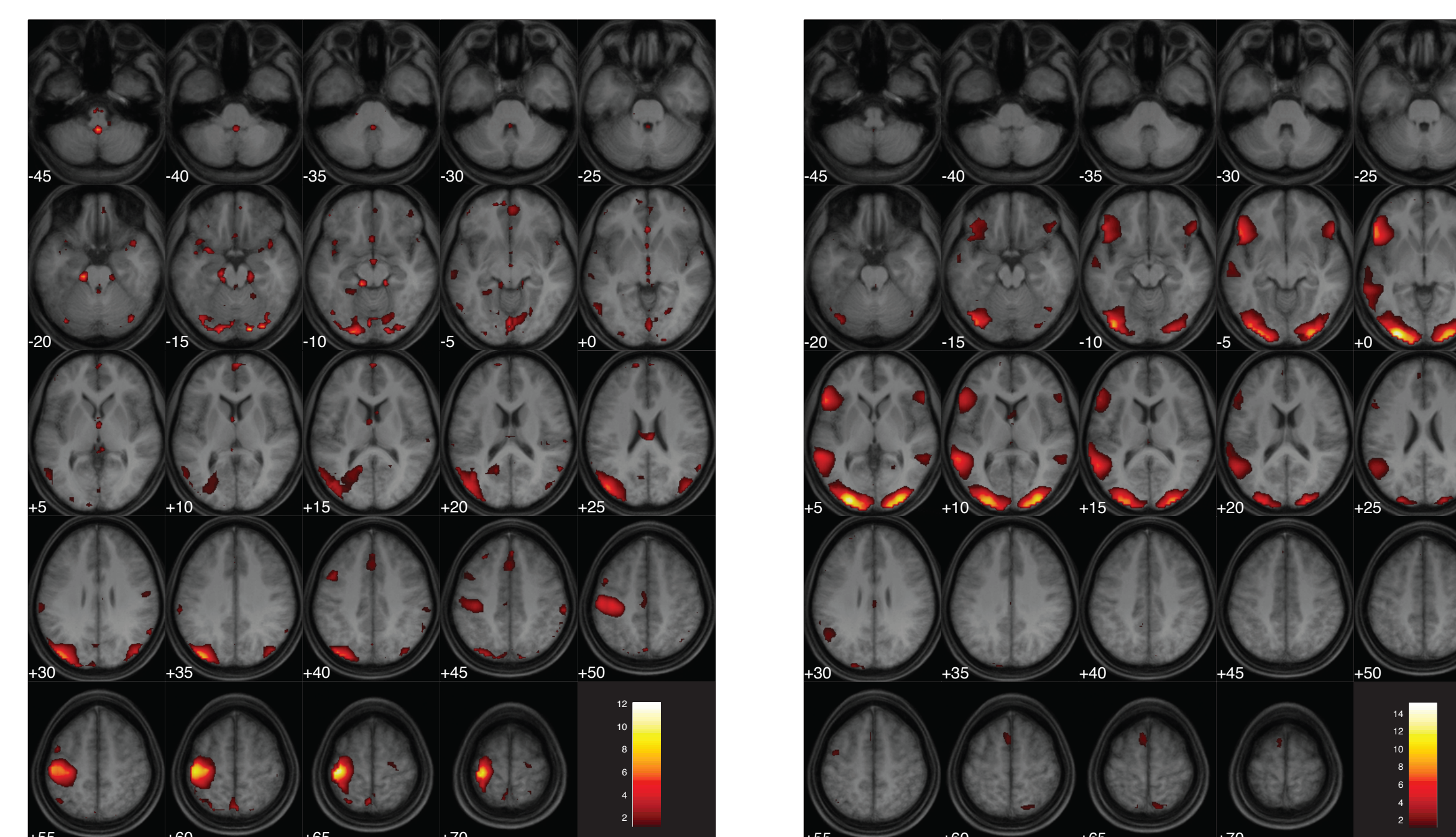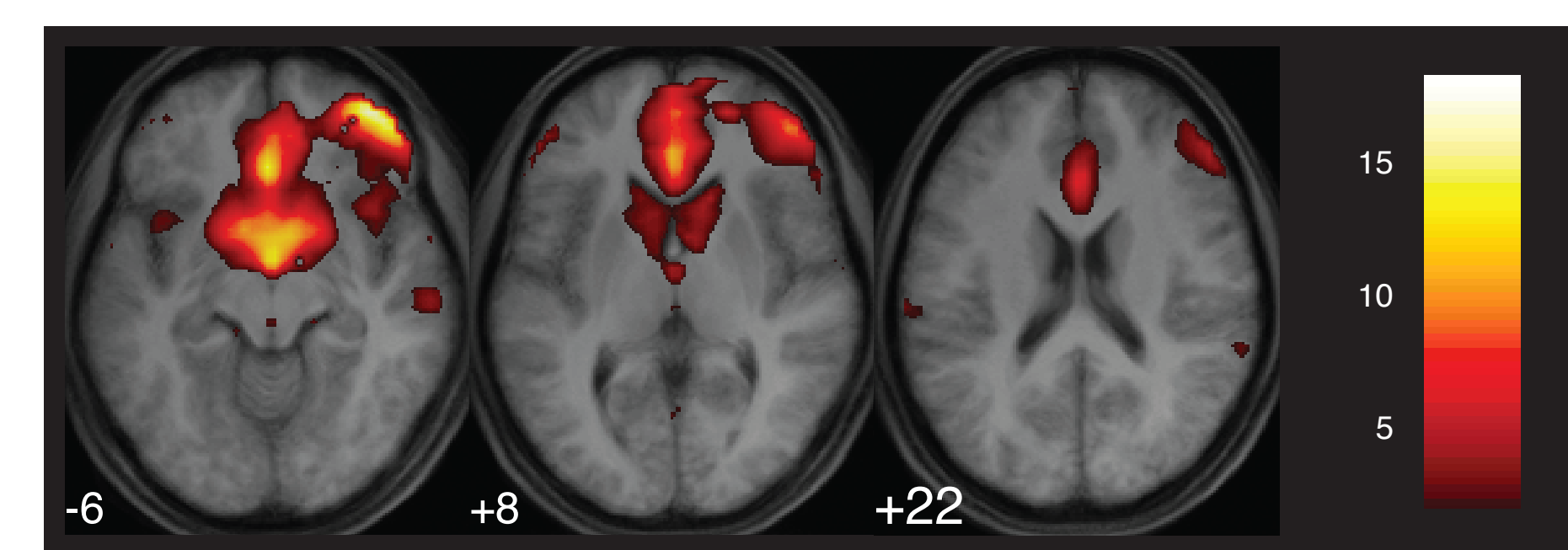

Main Effect: Faces (18 cmps)   Main Effect: Velten (6 cmps)

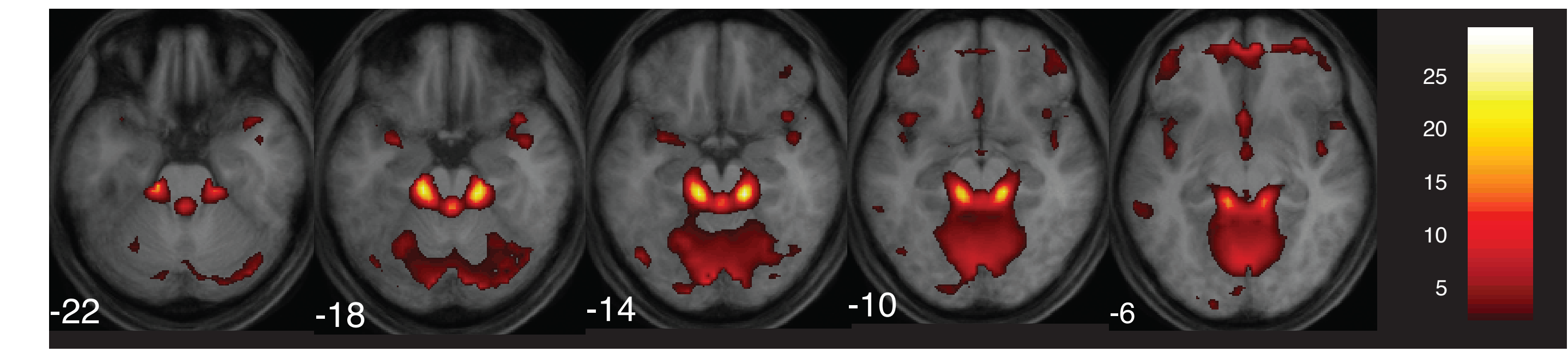Component cluster maps for main effects of affect induction tasks.
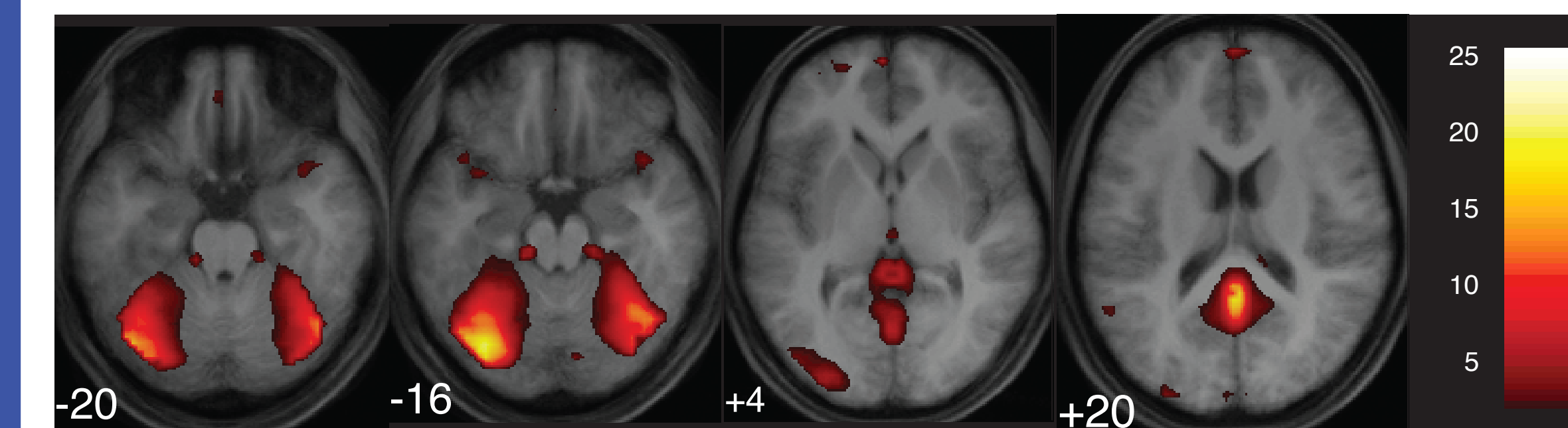
Results: Music-Evoked Nostalgia
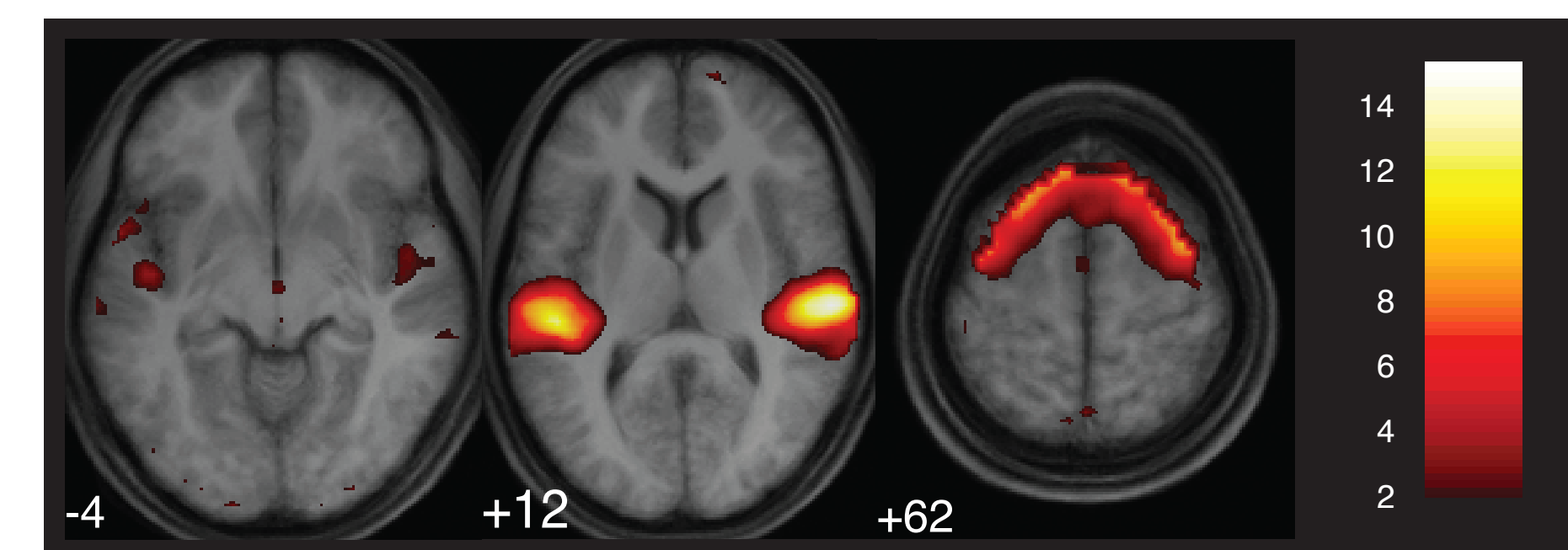
Component cluster for music playing and response cues (2 components).
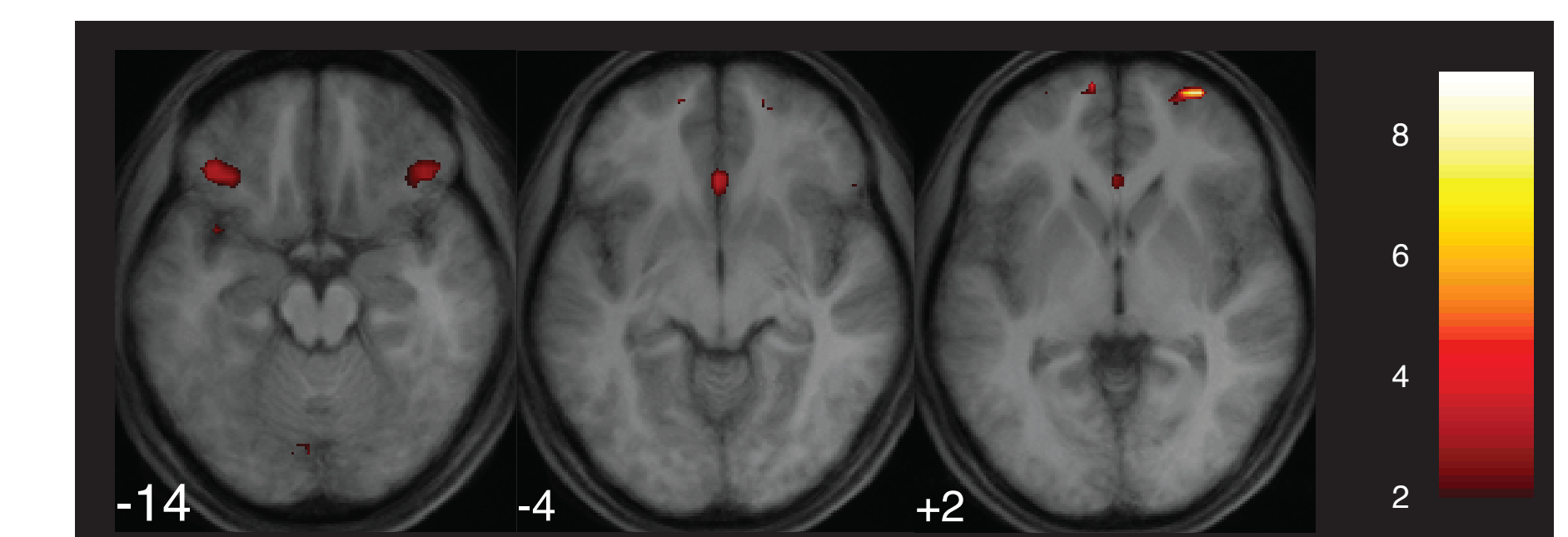

Component cluster for music-evoked autobiographical salience (3 components).

Component cluster map for music-evoked nostalgia (6 components).


Happiness

Sadness

Component cluster maps for happiness (3 components) and sadness (1 component) experienced during music listening.

## Study 2: Music-Evoked Spiritual Experiences

22 adults (10 females; age: 27-80yo; mean: 44.6 +/- 13.6) listened to (14) 2m excerpts, selected from stimuli that were chosen by participants for spiritual salience. After each sample, they rated the degree to which they had experienced Autobiographical Memories, Spiritual Experience, the Urge to Move, and the degree to which the song was pleasing, on a 5pt rating scale. Data were analyzed using the same methods as Study 1. GIFT estimated that 155 components were necessary to characterize these data.
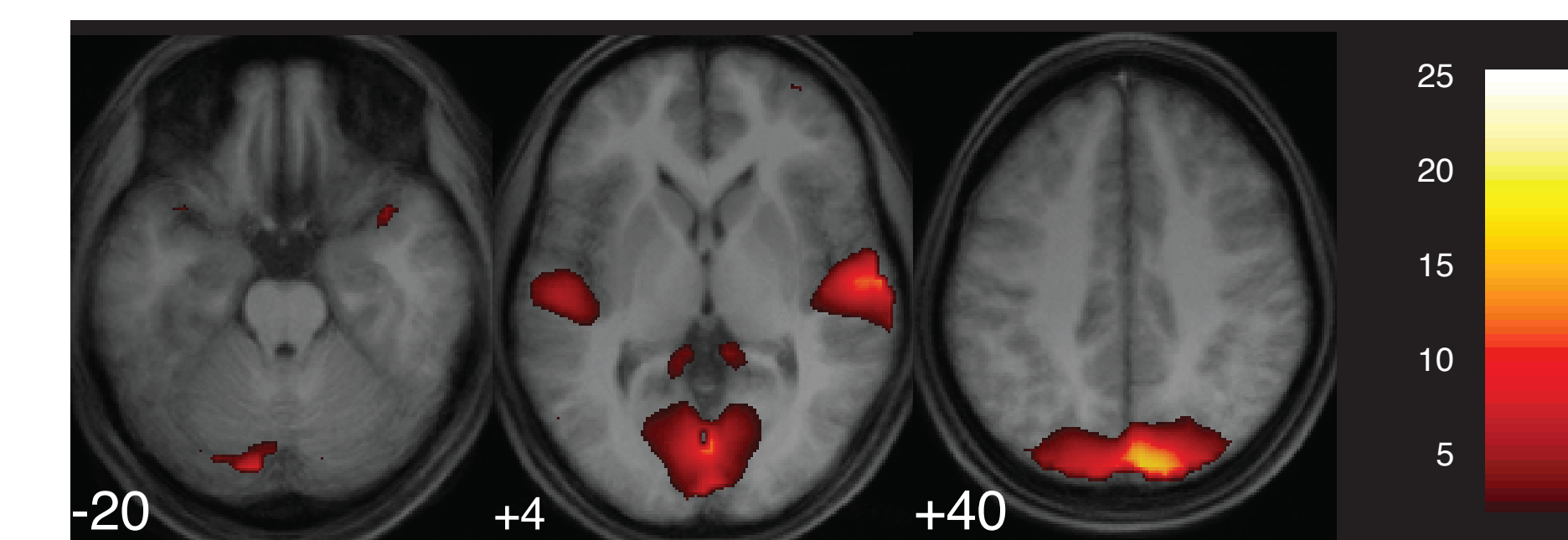
Component cluster for music playing and response cues (5 components).
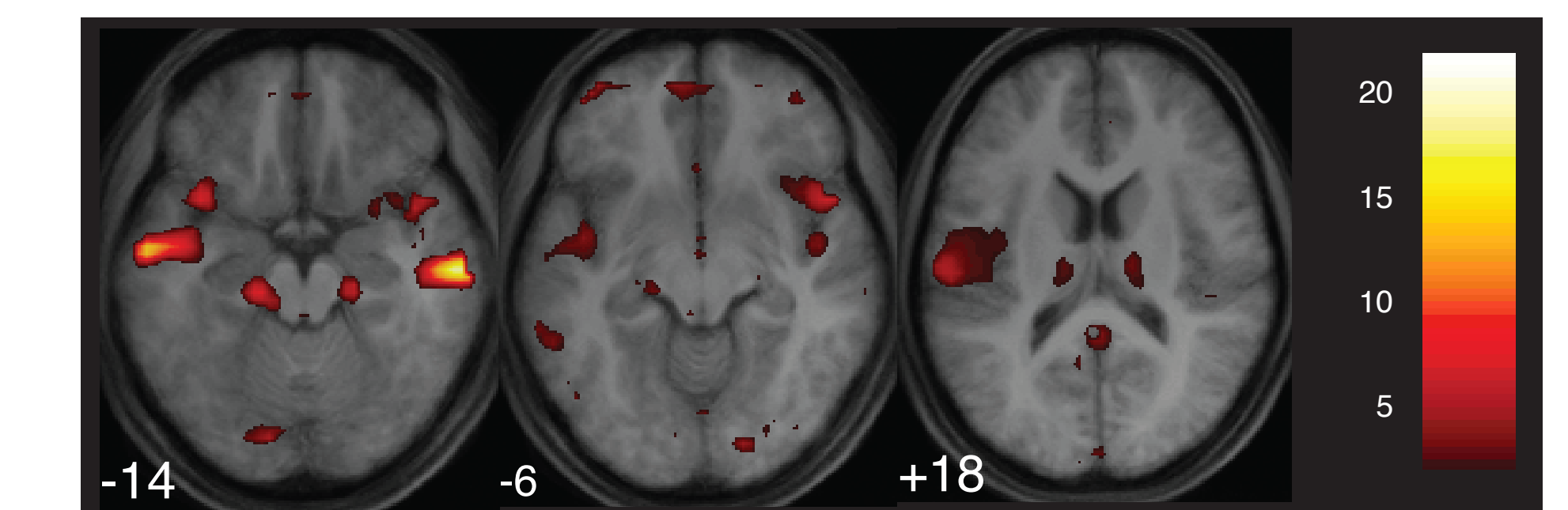
Component cluster for music-evoked spiritual experiences (6 components).
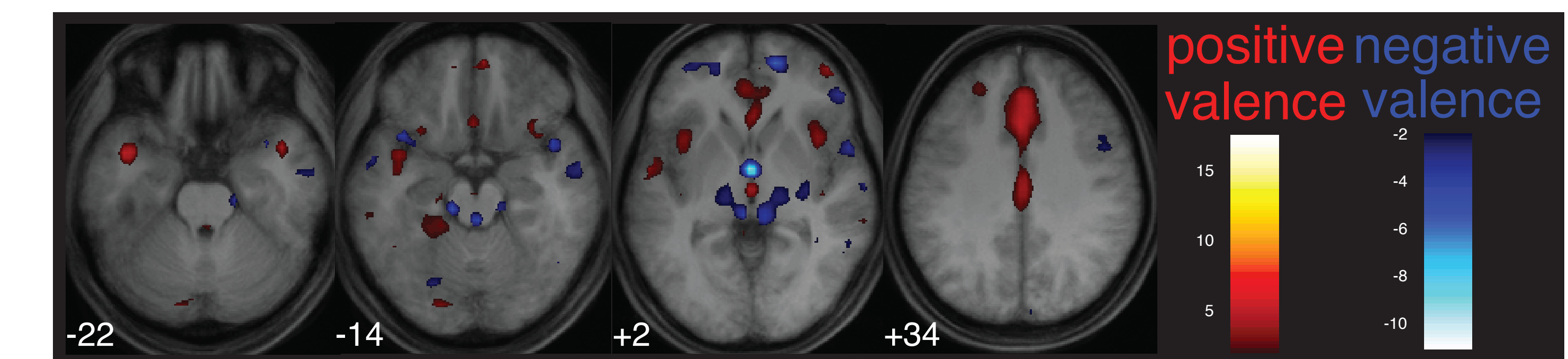
Component cluster for valence of experience during music listening (2 components).

Temporal Pole: Common Across Tasks

All tasks activated a spatial component in the temporal pole whose timecourse was predicted by the valence of the given affective experiences. This area has been reported to couple complex multi-modal stimuli with visceral emotional experience, and plays a role in empathy, in clinical disorders with socio-emotional regulation impairment, and in storing and retrieving emotionally salient personal episodic memories (Olson, 2007).
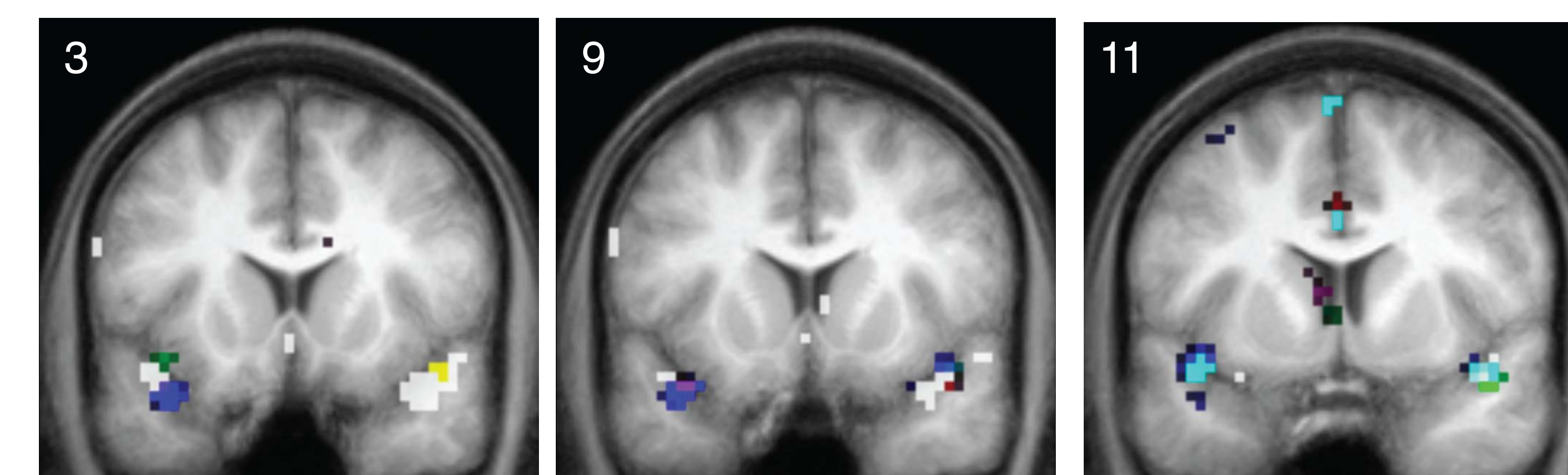
A 9-way conjunction between all affective component clusters reveals voxels in both right and left anterior temporal lobe that are activated in all tasks (shaded in white).

Conclusions

We used a variety of musical and non-musical tasks to evoke happiness and sadness within individuals. Each task recruited the temporal pole. These findings, as well as anatomical connections between temporal pole, amygdala, and prefrontal and orbital cortices, support the role of the anterior temporal lobe in the processing of emotionally salient complex stimuli. These findings provide converging evidence across different tasks, paradigms, stimulus modalities, and participant samples for a neural substrate underlying both musical and non-musical emotional experiences.