Multisensory circuits are embedded in sensory cortex hierarchies

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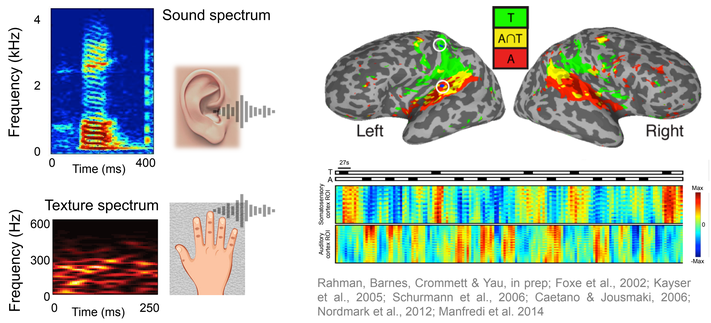
Introduction

- Traditional studies show that the areas in the somatosensory cortex respond to touch and areas in the auditory cortex respond to audition.
- Studies also provide evidence that some areas in somatosensory and auditory cortex respond to both touch and audition.



Rahman, Barnes, Crommett & Yau, in prep; Foxe et al., 2002; Kayser et al., 2005; Schurmann et al., 2006; Caetano & Jousmaki, 2006; Nordmark et al., 2012; Manfredi et al. 2014

- Do the responses of these auditory and somatosensory areas depend on stimulus features, e.g. frequency of audition and touch?

Objectives

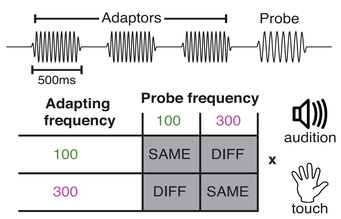
1. Identify brain regions that exhibit frequency-selective fMRI response patterns to touch and/or audition.
2. Establish evidence for hierarchical organization of the frequency-selective areas in the somatosensory and auditory cortical systems.

Methods

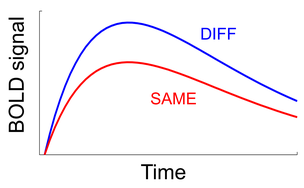
Functional MRI experiments

- 20 subjects scanned; 3T scanner
- Three types of scans per subjects
  - Block design localizer (no task) Reproduces previous studies
  - Event related adaptation paradigm (frequency discrimination task) Addresses *objectives 1 and 2*
  - Resting state (no stimulus/task) Addresses *objective 2*

fMRI adaptation paradigm



Predicted response – repetition suppression



Data analysis and visualization:

- fMRI data preprocessing using *AFNI* and *FreeSurfer*; Univariate and multivariate analysis using *AFNI* and *Matlab*; Surface data visualization using *SUMA*.

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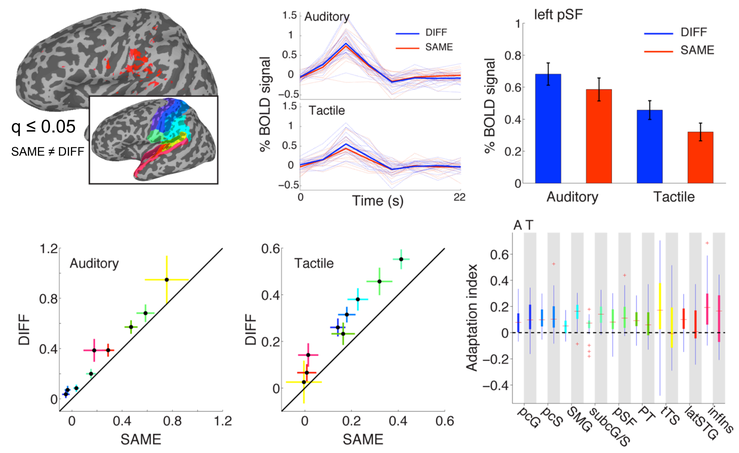
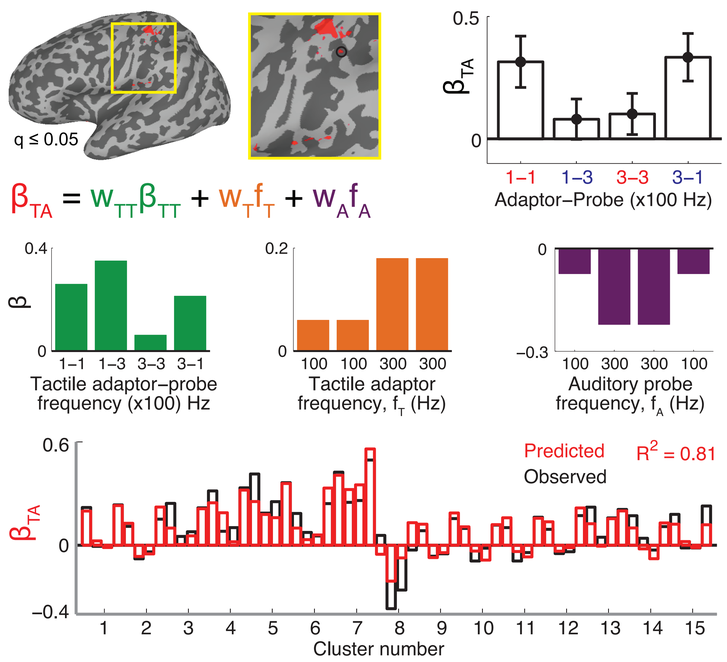
Results: Objective 1

1a. Multiple sensory brain regions respond to *unimodal* auditory and tactile signals in a frequency-dependent way



- Multiple brain regions show repetition suppression effects consistent with frequency-tuning for both auditory and tactile stimuli
- Despite differences in overall response magnitude, strength of adaptation is comparable across areas

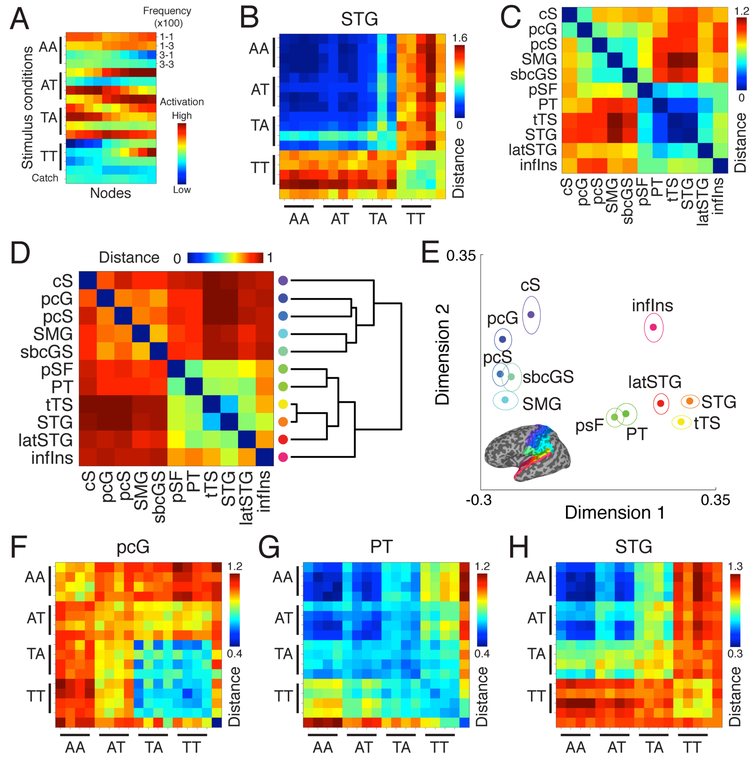
1b. Frequency-dependent interactions between *cross-modal* audition and touch are distributed over parietal lobe regions



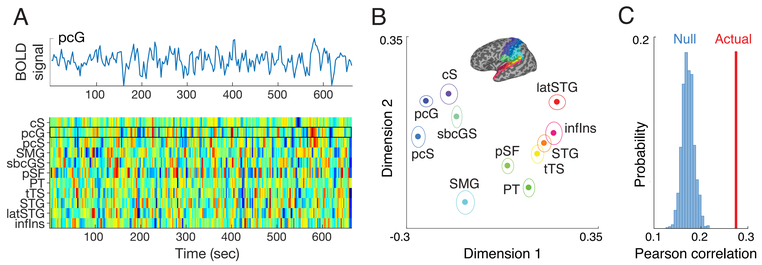
- BOLD responses on crossmodal (TA) events can be understood as a combination of repetition suppression and frequency-specific inhibition

Results: Objective 2

2a. Representational geometry of sensory responses across the parietal and temporal lobes reflects traditional cortical hierarchies



2b. Intrinsic architecture derived from patterns of spontaneous BOLD signal fluctuations also reflect cortical hierarchies



Conclusions

- Multiple sensory brain regions respond to unimodal and cross-modal auditory and tactile inputs in a frequency-dependent manner.
- Representational geometry of sensory responses, in addition to patterns of spontaneous signal fluctuations, reflects traditional hierarchical organization.
- Temporal frequency responses in the human brain is consistent with both multimodal processing mechanisms and traditional sensory cortex hierarchies.