Sensitivity to information about face shape in the fusiform gyrus of congenitally blind individuals

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Introduction

➢ Question: Why do studies show a stimulus domain by sensory modality interaction in the high-level visual shape region (the ventral occipitotemporal cortex, VOTC)?

- Functional preference for the **inanimate domain** is observed regardless of stimulation modality (visual/auditory/tactile) and subjects' visual experience (sighted/blind individuals), whereas preference for the **animate domain** seems robust only in the visual modality [1].

➢ Conjecture: Object domains differ in degree of transparency of mapping between high-level visual shape representation and action system computations [1].

- The **inanimate domain**: stable mapping between shape and potential action values (e.g., elongation – a particular type of grip) → development of mechanisms promoting interactions between the inanimate objects' shape representation and the action system (specific parsing of visual representation, connectivity) → this makes the inanimate objects' shape representation accessible through different modalities.
- The **animate domain**: shape is relevant for categorization/identification, but is not transparently linked to appropriate actions (e.g., similarly looking animals/humans might be dangerous or not) → lack of mechanisms promoting direct interactions between the animate entities' shape representation and the action system → the animate entities' shape representation is, in most cases, not readily accessible through other sensory modalities.

➢ This conjecture is relevant to a current debate: Do the **VOTC face areas** show preference for auditory and tactile stimuli related to the human face?

➢ Prediction derived from our conjecture: it depends on the type of face shape representation evoked and its relationship with the action system.

- The VOTC face areas will show preference for **facial expressions** – stereotypical face shapes that (a) systematically map onto the action system (e.g., compare happiness to anger) and (b) we experience and are able to perform ourselves – through the auditory or the tactile modality.
- The VOTC face areas will **not** show preference for **static facial features** – critical for identification, but no systematic relationship with the action system – through the auditory or the tactile modality.

➢ Experiment: 20 congenitally blind and 22 sighted participants in an fMRI experiment. They listened to inanimate object sounds and 4 animate sound categories: emotional and non-emotional facial expressions (e.g. crying vs. sneezing; high shape-action mapping transparency) as well as speech sounds and animal sounds (low shape-action mapping transparency).

Five categories of sounds in the fMRI experiment

Emotional facial expression sounds	Non-emotional facial expression sounds	Speech sounds	Animal sounds	Object sounds
(laughing and crying)	(yawning and sneezing)	(Chinese characters)	(a dog, a horse, a cow, a rooster)	(a car, a traffic, a church bell, sleigh bells)

Results

Figure 1. Blind subjects: the fusiform face area (FFA) showed robust functional preference for both types of facial expression sounds; in contrast, no functional preference, compared to object sounds, was observed for speech sounds or animal sounds.

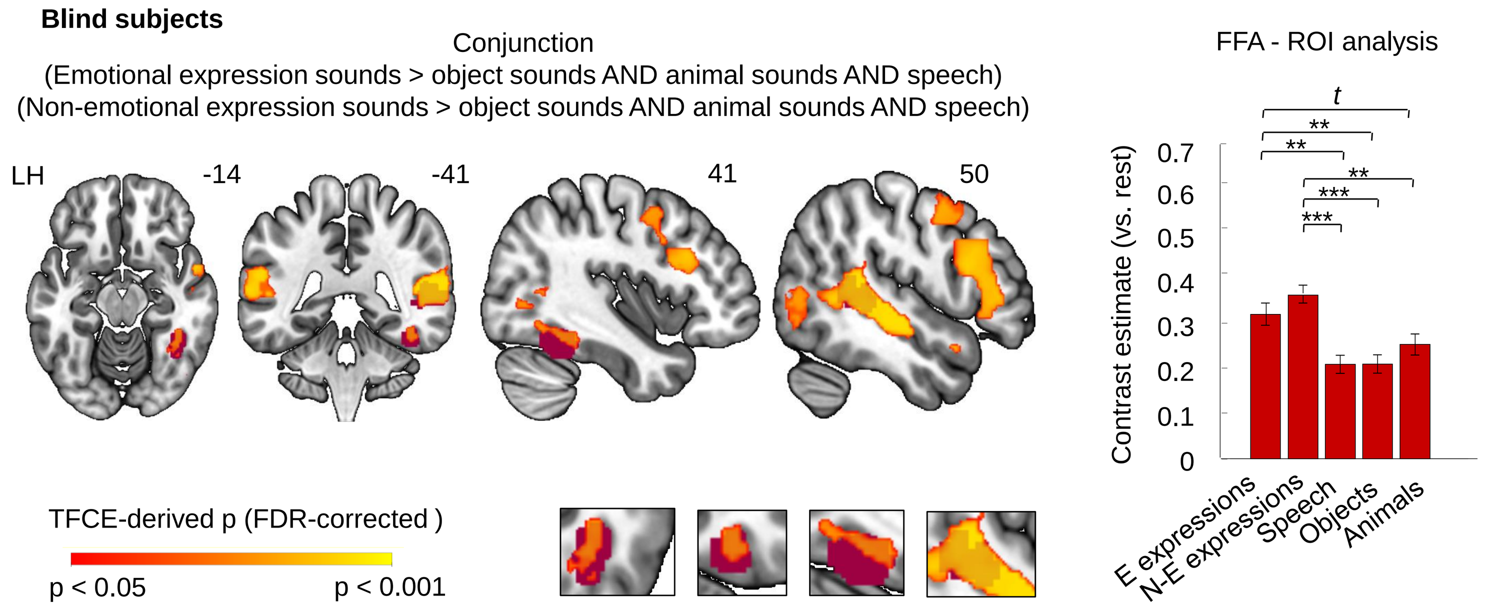


Figure 2. In the sighted subjects, no preference for animate sound categories was observed in the FFA.

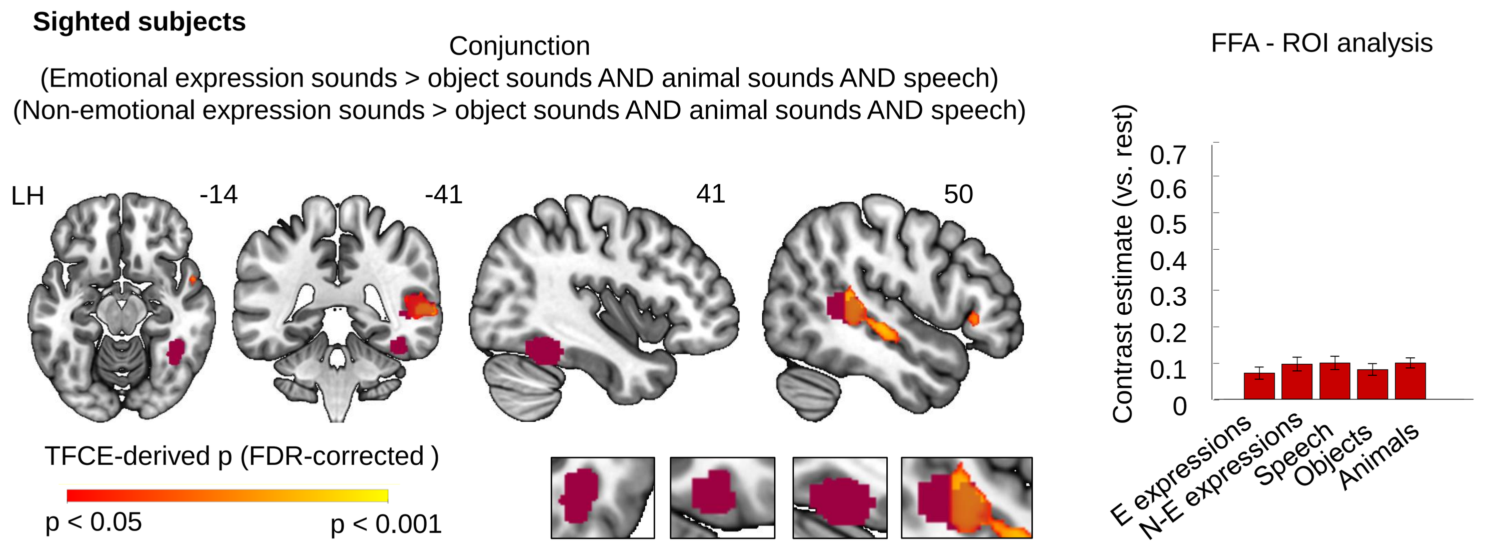


Figure 3. MVPA decoding: Relative to other sound categories, facial expression sounds induce distinctive activation patterns in the FFA, in both groups (despite no signs of univariate differences in the sighted subjects – see Fig. 2).

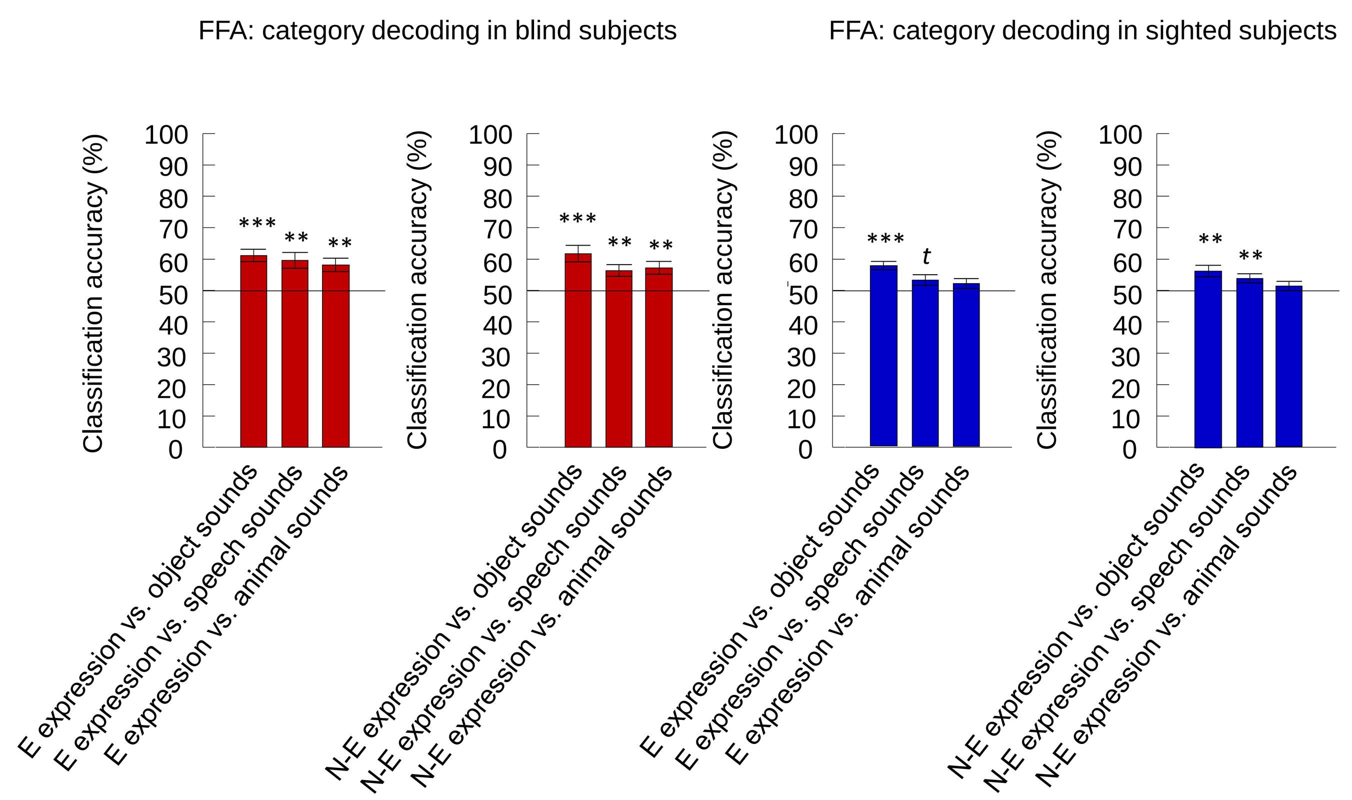
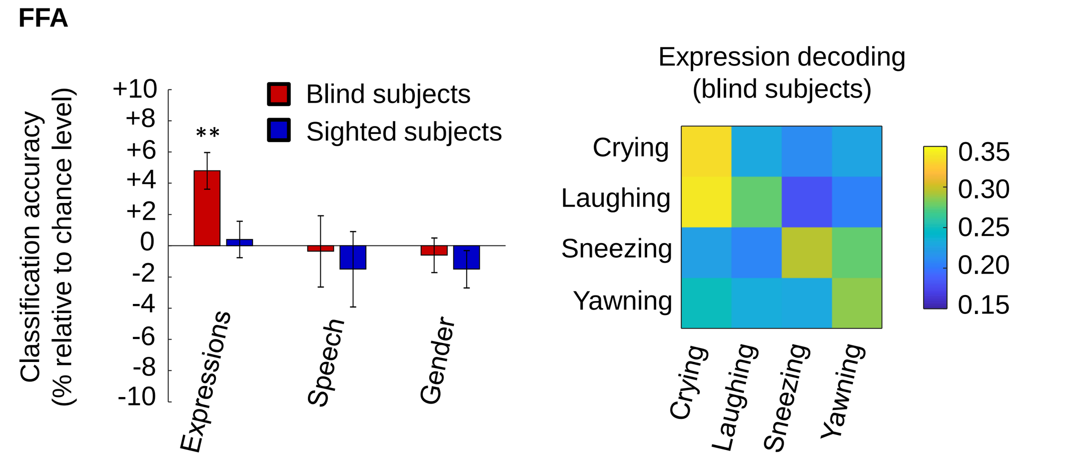


Figure 4. MVPA decoding: Distinctive pattern of activation for sounds of specific facial expressions in the FFA in the blind subjects (control analysis: No effects for specific speech sounds or the gender of two actors producing the sounds).



Summary

➢ We found dissociation between responses for the facial expression sounds (transparent shape-action mapping) and the other animate sound categories (low shape-action mapping) in the typical location of the FFA in blind participants. This suggests that shape-action mapping guides the auditory responsiveness of the FFA.

➢ The difference in shape-action mapping transparency across domains may explain the stimulus domain by sensory modality interaction in the VOTC.

➢ Contrary to findings for the inanimate domain [2, 3, 4], univariate activations for facial expression sounds differ across blind and sighted group.

- Inhibitory processes operating in the fusiform gyrus of sighted individuals? Given that animate representation in this region is almost exclusively visual, the suppression of signals from other senses might be desirable [5].

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