

A functional localizer for identifying brain regions engaged in prosodic processing in individual subjects

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Prosody is an important cue for constraining interpretation. Brain imaging methods – fMRI in particular – have the potential to shed light on the mechanisms that support prosodic processing, but one widespread problem with previous neuroimaging studies of language is that they almost exclusively rely on group-based analyses where brains are aligned in a common space. Due to inter-individual differences in brain anatomy [1-3], functional activations do not line up well, leading to decreased sensitivity and selectivity [4-6]. Furthermore, traditional group analyses make it difficult to establish a cumulative research enterprise because if different patterns of results are obtained across studies, there is no way to determine which results are (more) valid [7].

We propose an alternative method in which regions of interest are i) defined functionally in each subject individually, and then ii) characterized by examining their response to new conditions of interest [8]. This method has been successful in characterizing regions that support high-level vision, social cognition and more recently language [5,9]. Here we develop a functional localizer for regions sensitive to sentence-level prosodic information. Participants (n=12) were presented with sentences (S), word lists (W), jabberwocky sentences (J) and nonword lists (N). Half of the stimuli were presented visually, half – auditorily. Sentences and jabberwocky, but not word/nonword lists, involve combinatorial (syntactic and/or compositional semantic) processing. The classical language regions (Broca's and Wernicke's areas) show a similar functional profile across modalities, responding more to sentences than word lists and more to jabberwocky than nonwords [5,10]. However, in addition to their combinatorial properties, the auditory version of each sentence/jabberwocky-string has a sentence-level prosodic contour, while the word/nonword lists lack such a contour. In contrast, this difference does not exist to the same extent for the visual versions of these conditions.

To search for regions sensitive to sentence-level prosodic information, we selected voxels in each individual brain that (i) showed a significant SJ>WN effect in the auditory conditions, and (ii) did not show such an effect in the visual conditions. We then performed a group-constrained subject-specific analysis [5] to see if activations are spatially similar across subjects. Four prosody-sensitive regions emerged, each present in at least 9/12 subjects: a region near the right temporal pole (previously implicated in prosody; 11-12), a region in the posterior inferior temporal gyrus, and their left-hemisphere homologues. We examined the replicability of the functional response of these regions using a left-out portion of the data. All four regions showed a selective response to prosody, with a significant SJ>WN effect in the auditory conditions ($F_s > 4.6; p_s < .001$), and no such effect in the visual conditions ($F_s < 1.5; n.s.$).

The ability to quickly and reliably define brain regions sensitive to sentence-level prosodic information opens a door to a research program investigating (a) which aspects of prosody these regions are sensitive to, (b) how prosodic processing interacts with syntactic/semantic processing

to convey different aspects of meaning, and (c) whether these regions are functionally specialized for prosodic processing vs. supporting some non-linguistic functions, like music or social cognition, both of which have been shown to activate anterior temporal regions [13-15].

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