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The neural correlates of spatial deictics: a fast fMRI study using naturalistic auditory stimuli

Abstract:

Spatial demonstratives, i.e. words like this and that, are lexical items used to indicate contextual distance. In spite of their minimal semantic specificity, they can trigger attentional shifts and establish a joint focus of attention on referents in the physical environment, thus functioning as interfaces between linguistic representations, attention and perceptual processes.

No research has been conducted on how this peculiar intertwining between linguistic, attentional and perceptual processes is implemented in the brain.

This may be due to the fact that studying demonstratives raises methodological challenges. As their meaning hinges on the context of utterance, attempts at investigating their neural underpinnings call for the need to simulate rich linguistic and physical environment within the constraints intrinsic to neuroimaging.

With these challenges in mind, we conducted a naturalistic fMRI experiment (N = 28) where participants listened to specially crafted dialogues with a controlled number of spatial demonstratives (as well as a number of other function words). The dialogue involved two synthesized voices, each recorded onto a separate channel of a stereo track. This allowed to embed the target words in both a rich linguistic context, and a 3D-like spatial setting. A fast acquisition sequence (TR = 388ms, multi-band EPI acquisition) was used to capture signal changes at word-level resolution, relying on evidence for the presence of high-frequency components in the BOLD signal (Lewis et al., 2016).

We isolated regions involved in processing spatial demonstratives via random effects univariate analyses, modelling neural response via FIR models and using RETROICOR cardiac and respiratory models for denoising.

We found bilateral posterior superior parietal activation in response to spatial demonstratives in areas associated to attentional orienting and functional representation of space, with activation being significantly stronger for distal than for proximal demonstratives. These results are compatible with behavioral evidence showing that spatial demonstratives are likely to encode the attentional status of the referent, as well as its functional perceptual-motor features (e.g. graspability).
Additionally, we submitted the parameter estimates from the univariate model to multivariate pattern analysis, so to identify patterns specific to the representation of spatial demonstratives compared to other types of referencing expressions.

Our results contribute to establishing a grounding of neural representations for spatial demonstratives onto non-linguistic perceptual and attentional resources. They also contribute to validating fast fMRI paradigms using naturalistic auditory stimuli as a reliable experimental procedure to investigate language phenomena at short time scales, within rich contexts and at a computationally sustainable cost.