

Title: Discourse belief-updating in the right hemisphere

Introduction. The ability to communicate about things outside the here-and-now is a core trait of human language¹, yet its neural underpinnings are understudied. This study investigated the contribution of modal verbs, words that refer to possible states of affairs that are not actual or known. Factual assertions (e.g. ‘John loves Mary’) are claims about the world under discussion which can be either accepted or rejected, allowing you to update your beliefs about this world accordingly². In contrast, modal statements (e.g. ‘John must love Mary’) do not make claims about the actual world directly, rather they postulate possible scenarios that are compatible with the world under discussion³. In this study we investigated the neural mechanisms underlying the processing of assertive verbs (like *do*) and modal verbs (*may* and *must*) in order to gain insight into the basic brain mechanisms of modal processing.

Methods. A magnetoencephalography (MEG) study (N=25) compared visually presented sentences (rapid serial visual presentation) containing the ambiguous modals ‘may’ and ‘must’ against sentences containing the non-modal verb ‘do’. In order to have *do* naturally appear in the same position as *may* and *must*, our sentences contained VP ellipsis (... and the squires do/may/must too), controlled for elided-VP length and complexity (Fig 1). The interpretation of the ambiguous modals was dependent on prior (pre-normed) contexts biasing towards either an inferential (epistemic) or permission/obligation (deontic) reading. Target sentences (N=240) were followed by a task sentence, where participants indicated whether these were natural continuations of the story or not.

Results We did not find any significant differences between the different types of modal verbs nor reliable activity increases for modal verbs in general. Instead, a full-brain analysis in the time window 100-900ms after target word onset revealed a significant spatio-temporal cluster (Fig 2) reflecting a robust increase for the non-modal conditions over modal ones, at 210-350ms starting around the right Temporoparietal Junction (rTPJ) and spreading up to the right Inferior Parietal Sulcus (rIPS) and right medial surfaces (cuneus - posterior cingulate cortex).

Discussion. We hypothesize that this increased activation for the non-modal condition may reflect computations involved with evaluation and integration of claims made about the world of evaluation, a process absent from the modal condition as those sentences only contribute possible compatibilities with the evaluated world. This belief-updating function is in line with suggestions that the rTPJ plays a role in theory revision and conceptual change^{4,5} and supports that the right hemisphere is involved in pragmatic processing and contextual coherence^{6,7,8}.

Follow up. In order to gain a deeper insight into the neural correlates of discourse integration and belief-updating we are now conducting a follow up experiment where we investigate the processing of *do/may* and *might* embedded in factual (asserting), conditional (hypothetical) and presupposed (taken to be in common ground but not asserted) statements (Fig 3). We hope to replicate the proposed belief-updating effect in the factual environment, and then see whether this effect is modulated by the level of hypotheticality of the embedding statements.

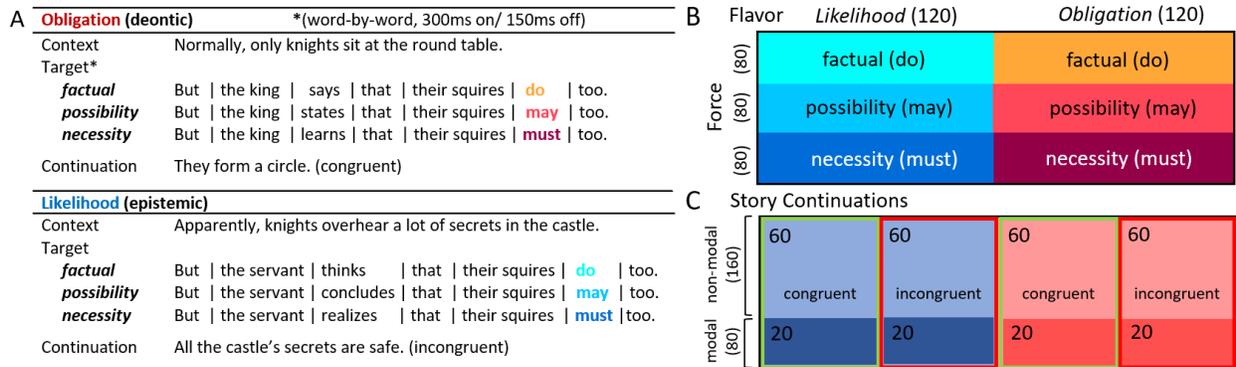


Figure 1. A. Example Stimulus Set; B. Experimental design; C. Task Items

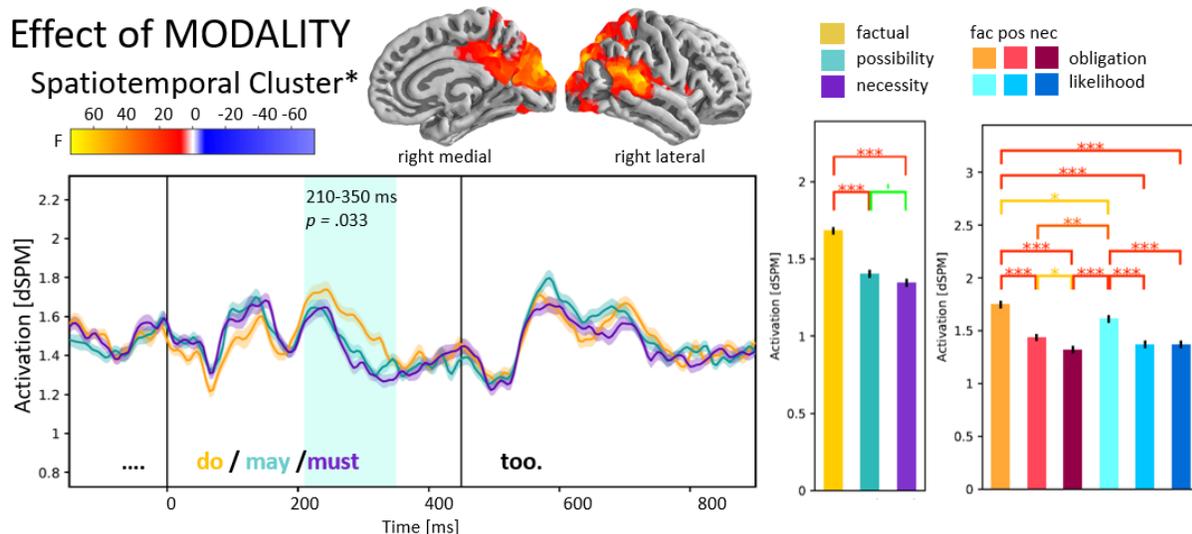


Figure 2. Average activation (dSPM normalized measure) of spatiotemporal cluster. Results come from cluster-based permutation multivariate 2(flavor) X 3(force) ANOVA, minimum cluster 25 ms and 10 sources, 10,000 permutations)

(Targets presented word-by-word, 300ms on/ 150ms off)

Context	CASTLE								
Condition	<i>factual</i>	Knights	own	many	weapons,	so	their squires	do /may/ might	to.
	<i>conditional</i>	If	knights	own	weapons,		their squires	do /may/ might	to.
	<i>presupposed</i>	Since	knights	own	weapons,		their squires	do /may/ might	to.

Figure 3. Design follow up experiment

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