Towards a causal role for Broca's area in language processing:

A TMS-EEG approach testing syntactic prediction in the left Inferior Frontal Gyrus

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Linguistic expressions consist of word sequences organized into hierarchies of nested phrases. According to a prominent hypothesis in theoretical linguistics, the human brain must be endowed with a simple combinatorial mechanism (Merge) driving language comprehension to build hierarchies out of single words. In the first part of the talk we will discuss three fundamental empirical facts concerning the where, when and how of Merge processing in the human brain: (1) Where – BA44 in the left Inferior Frontal Gyrus (IFG) appears to be consistently recruited during the processing of linguistic hierarchies, independently of the complexity of the linguistic stimulus and the availability of semantic information. Activity in BA44 reduces to its most ventral-anterior portion at the most fundamental two-word linguistic level, when very basic hierarchical phrase structures are built (e.g. *a book*), thus indicating region's strong involvement in syntactic hierarchical building. (2) When – Word-category violations at the two-word level during on-line language processing result in an Early Syntactic Negativity deflection, functionally equivalent to the Early Left Anterior Negativity observed in complex syntactic contexts, peaking in the electroencephalographic signal around 180-220ms after violation detection (e.g. *a reads). (3) How – Category-based parsing models (e.g. left-corner, bottom-up) outperform sequence-based parsing models in predicting unique variance in neural activation in Broca's region during natural language processing. In the second part of the talk, we begin to bring these three empirical facts together in one single experiment to test whether Broca's area *causally* supports the Merge mechanism for language by means of some specific category-based parsing strategy. We thus present an experiment simultaneously combining Electroencephalography (EEG) with Transcranial Magnetic Stimulation (TMS) in a two-word stimulus context, to more specifically verify whether Broca's area supports left-corner parsing strategies reflecting syntactic categorical prediction triggered by the first word (Determiner) about the following word (Noun). We reasoned that, if Broca's area generates categorical predictions in a left-corner fashion, the use of TMS interference during the first word would lead to a reduction of the Early Syntactic Negativity response. On the basis of our preliminary analyses comparing Broca's disturbance effect against the one recorded for the corresponding control site, our data fail to support a causal role of Broca's area in performing syntactic predictions by means of left-corner parsing strategy during on-line language processing. On this account, we review additional recent studies in line with the hypothesis of a bottom-up role of Broca's area for Merge.

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