

Left Posterior Inferior Frontal Gyrus is Causally Involved in Complex Sentence Comprehension

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Introduction

Storage and reordering of words are two core processes required for successful sentence comprehension. Storage is necessary whenever the verb and its arguments (i.e., subject and object) are separated by a long distance, while reordering is necessary whenever the argument order is atypical (e.g., object-first order in German, where subject-first order is typical). Previous neuroimaging work (Meyer et al., 2012) has associated storage with the left planum temporale (PT), and reordering with the left posterior inferior frontal gyrus (pIFG). However, it is unclear whether left PT and pIFG are indeed *causally* relevant for storage and reordering, respectively. Here, we tested the necessity of the PT and pIFG for storage and reordering using repetitive transcranial magnetic stimulation (rTMS).

Methods

We applied either effective online rTMS (5 pulses at 10 Hz) over PT or pIFG, or sham rTMS, while subjects listened to sentences that independently manipulated storage demands (short vs. long argument–verb distance) and reordering demands (subject– vs. object-first argument order). We employed behavioral modeling, using a drift diffusion model, to assess rTMS-induced disruption of sentence comprehension.

Results

We found that rTMS over pIFG, but not PT, selectively impaired reordering during the processing of sentences with a long argument–verb distance (Figure 1). Specifically, relative to sham rTMS, rTMS over pIFG significantly increased the performance decline for object– vs. subject-first long-distance sentences ($t_{23} = 2.86$; $p = 0.009$). This effect was anatomically specific as the same comparison for PT stimulation was far from significant ($t_{23} = -0.11$; $p = 0.9$), and a direct across-sites comparison showed that the pIFG effect was significantly stronger ($t_{23} = -2.62$; $p = 0.015$).

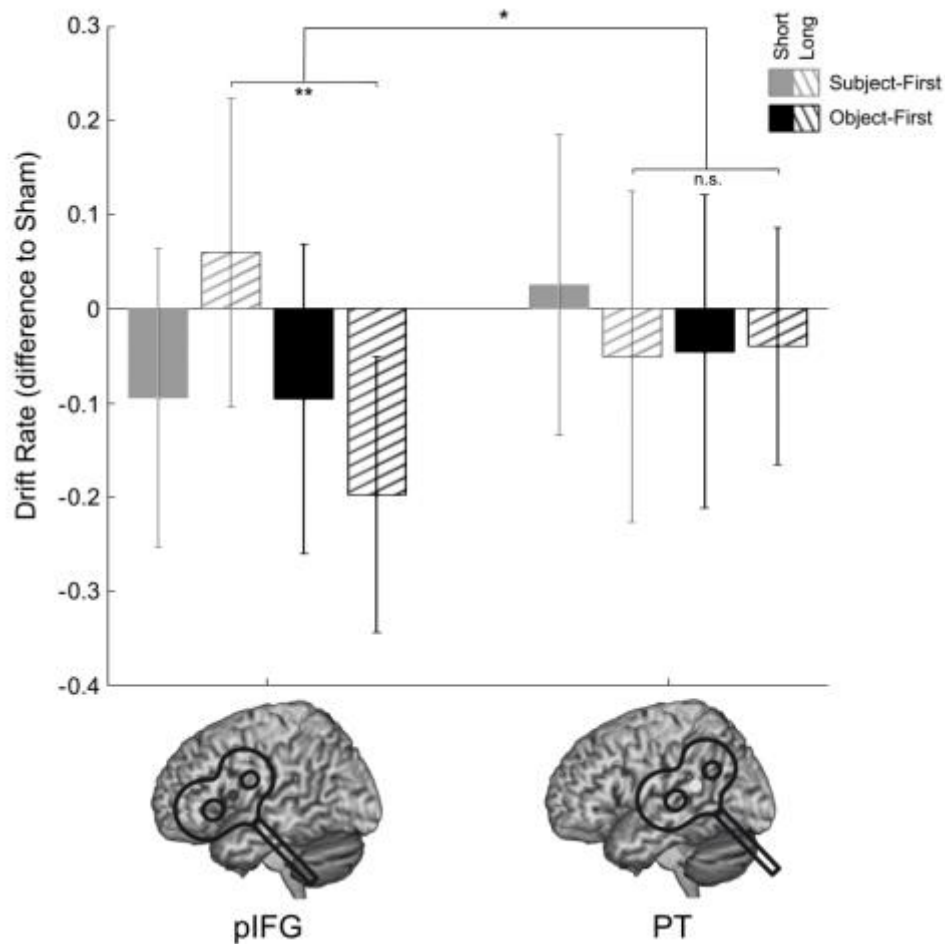


Figure 1. Mean rTMS effect on sentence comprehension performance (“drift rate” in the drift diffusion model), as compared to sham rTMS. Error bars represent standard error of the mean. n.s.: not significant, *: $p < 0.05$, **: $p < 0.01$.

Conclusion

Our results provide the first causal evidence that the left pIFG supports the reordering of arguments in long-distance sentences. We thereby substantially extend previous neuroimaging studies that showed a correlation between pIFG activation and reordering demands. Together with previous evidence (Lauro et al., 2010), our findings indicate that the left pIFG crucially supports the comprehension of syntactically complex sentences. These results might extend to other domains, such as music (Maess et al., 2001) and action (Clerget et al., 2009), indicating a domain-general role of left pIFG in the processing of hierarchically-structured sequences.

References

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