

Probing the neural correlates of argument structure: A fMRI study of naturalistic language



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Background

Verbs' argument structure guides language comprehension e.g. Boland (2005, 1993); Shapiro et al. (1991), Trueswell et al. (1993), McRae et al. (1998)

Various aspects of argument structure, such as diathesis alternations, selectional restrictions, and subcategorization have been studied using controlled, task-based designs.

Data Collection

Participants (n=51) were college-aged, right-handed, native English speakers.

Listened to a spoken recitation of *The Little Prince* for 1 hour and 38 minutes across nine separate sections; 15,388 words in total.

Comprehension was confirmed through multiple-choice questions at the end of each section (90% accuracy, SD = 3.7%).

Computational Metrics

- Excluding modals, auxiliaries, and gerunds, there are 1970 verbs attested in the story
 - 401 unique tokens
 - Identified using the NLTK toolkit and Stanford POS tagger.
- Diathesis alternations for a given verb was calculated from PropBank (Kingsbury, 2002).
- Selectional restriction was calculated according to Resnik (1996).
 - Estimated verb-direct object pairs from the Gigaword (Ferraro et al., 2014) & WaCkypedia (Baroni et al., 2009) corpora and then calculating the number of different WordNet semantic classes a given verb's direct objects falls into
- Syntactic subcategorization quantified using subcategorization frame entropy (Linzen et al. 2013).

Goals

Does thematic fit (operationalized through selectional restrictions) and thematic ambiguity (operationalized through diathesis alternations and subcategorization entropy) correspond to different brain regions?

Corroborate previous work on argument structure using naturalistic stimuli & computational metrics.

fMRI Analysis

Preprocessing was carried out with AFNI version 16 and ME-ICA v3.2 (Kundu et al., 2011).

GLM Analysis:

- Each predictor convolved with SPM12's canonical HRF, regressed against observed BOLD signal during passive story listening in 3 different models.
- Includes four regressors of non-interest: word offset, frequency, pitch, intensity

Results

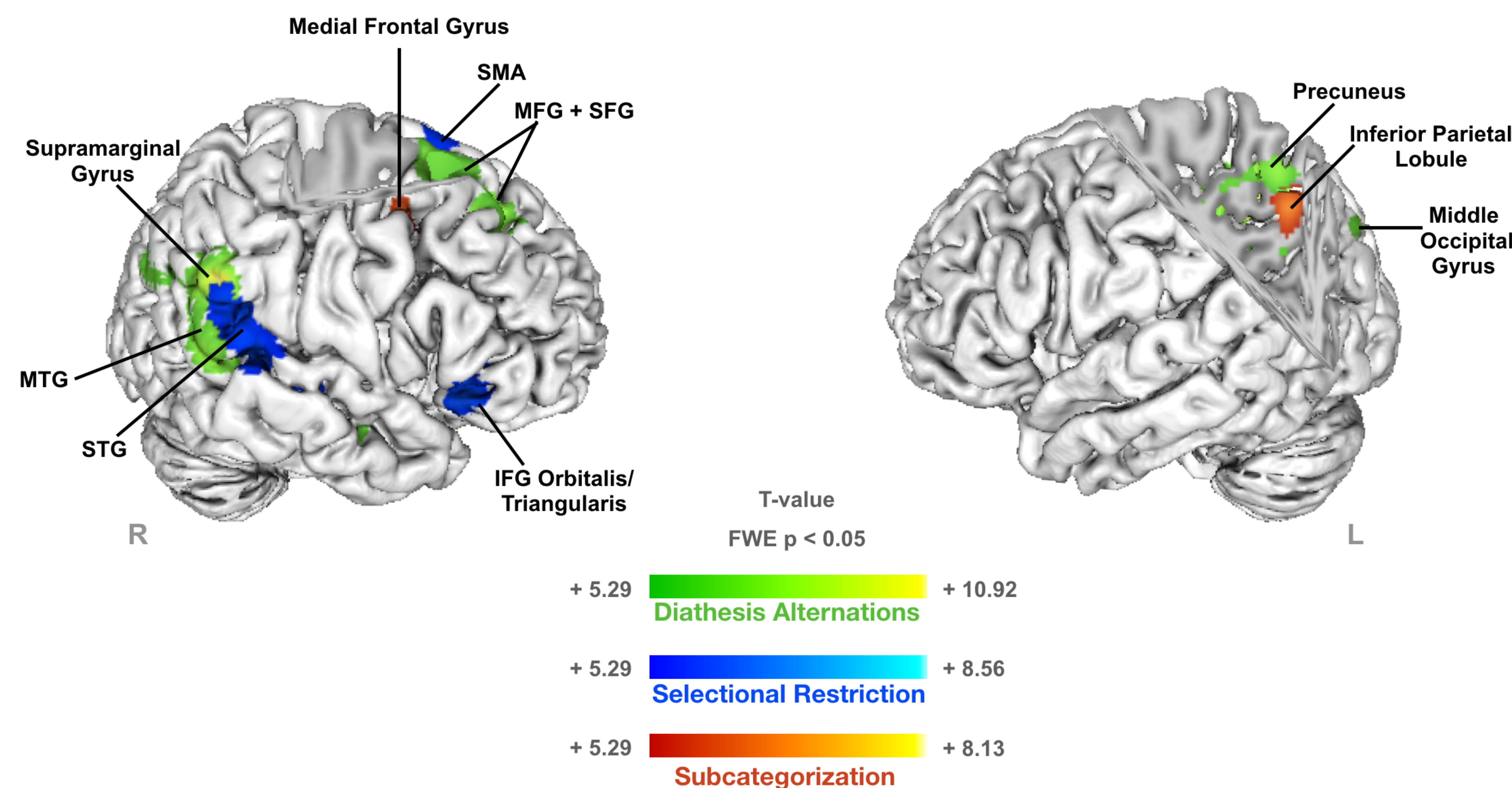


Figure 1: Whole-brain contrast images with significant clusters for diathesis alternations in green, for selectional restrictions in blue, and for subcategorization in orange after FWE voxel correction for multiple comparisons with $p < 0.05$.

Conclusion

- Results illustrate the centrality of supramarginal gyrus, posterior MTG & STG to processing verbs and its argument structure.
- Consistent with Thompson and Meltzer-Asscher (2014)'s neurocognitive model of argument structure processing.
- Corroborate existing work on argument structure e.g. Ben-Shachar et al. (2003); Shetreet et al. (2007, 2009, 2010); Thompson et al. (2007, 2010); Meltzer-Asscher et al. (2013, 2015); den Ouden et al. (2009), and Fabre (2017) among others.

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