

# Topology of the language network in a polyglot: largely overlapping brain activity

Jonna K. R. Hemming<sup>1\*</sup>, Shaza Haj-Mohamad<sup>1\*</sup>, Nicole E. Neef<sup>1,2</sup>

<sup>1</sup>Department of Diagnostic and Interventional Neuroradiology, University Medical Center Göttingen; <sup>2</sup>nicole.neef@med.uni-goettingen.de, \* equal contribution

**Introduction** Language-eloquent regions cover large parts of the cortex, particularly in the left hemisphere of the brain, including Broca's area in the inferior frontal cortex (IFG), as well as middle frontal gyrus (MFG), angular gyrus (AngG) superior and middle temporal regions (AntTemp, MidAntTemp, MidPostTemp, PostTemp) and the fusiform gyrus (FusiG). Activity in lateral temporal regions is commonly less lateralized. In contrast to the cortical language correlates, the cerebellum (Cereb) shows activity lateralized to the right [1]. Eloquent regions can be mapped with task-fMRI, which can improve outcomes in brain tumor resection [2]. Here we test the robustness of the topology of the fronto-temporo-parietal language network with respect to cross-linguistic variations and functional key properties such as lateralization across six languages in a polyglot subject [3].

**Methods**

**Participant**

- Age 75 years (male, right-handed)
- L1: Italian, German, Spanish, English
- L2: Portuguese, French

**MRI data acquisition**

- GE-EPI; TR = 1.5 s; 400 volumes per run
- MPRAGE (T1w image)

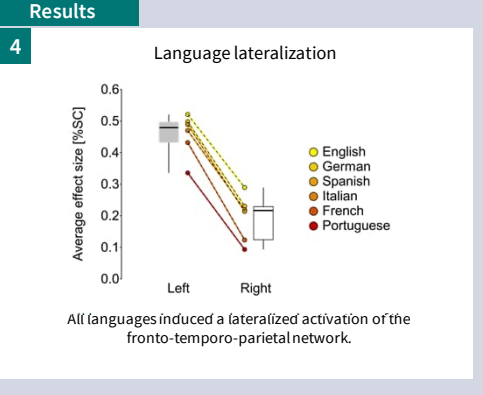
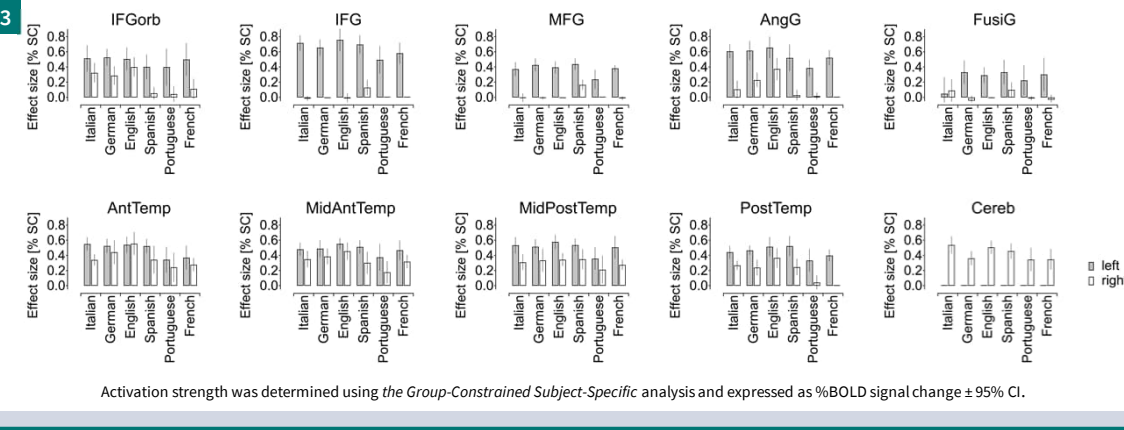
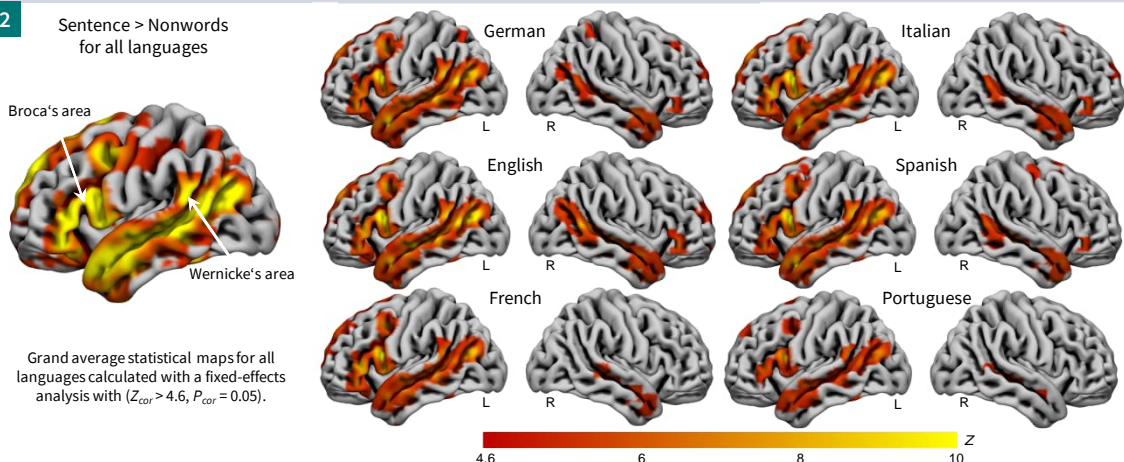
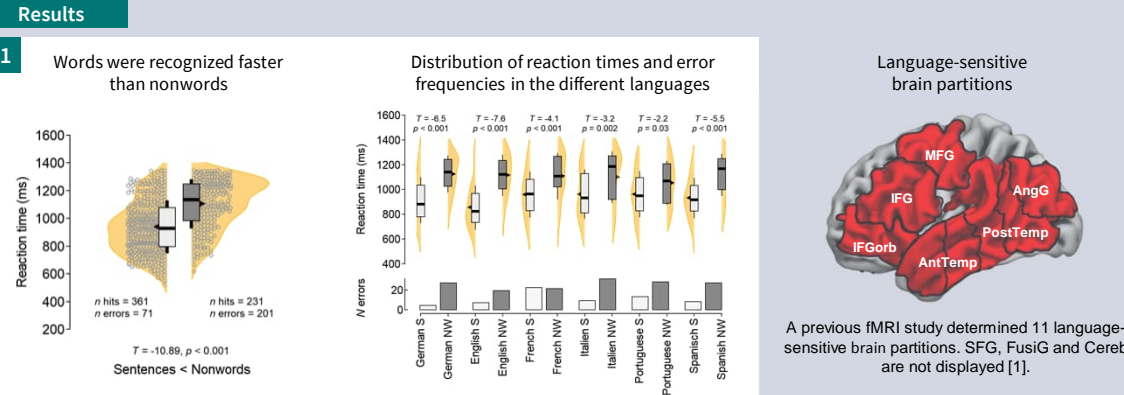
**Language paradigm**

- Sentences and nonword lists of 8 words
- 72 sentences and lists per language
- Sourced from literature classics in the Gutenberg Project library
- Probe at the end of each trial
- Randomized block design with 9 runs

Examples:  
*Les petites îles furent vite couvertes de maisons.*  
*kes sirités wres fulant léte coumistes di baivons*

**Data analysis**

- Fixed-effects GLM analysis to fit the hemodynamic response function
- Group-constrained subject-specific analysis for 11 ROIs in each hemisphere [1]



**Discussion** At the behavioral level, we replicated neurolinguistic findings for word processing compared to nonwords, which was reflected in shorter reaction times and higher accuracy for words. Performance varied between languages. At the brain level we were able to demonstrate robust activation of the language network for six different languages, with L1 languages showing slightly higher BOLD responses compared to L2 languages, particularly in the left IFG (Broca's region) and the posterior temporal cortex (Wernicke's region). Overall activation in left- and right-hemispheric language-sensitive regions was strongest for English and weakest for Portuguese, reflecting not only the developmental trajectory but presumably also current language use. There was a consistent lateralization of language-related activity towards the left hemisphere. Cerebellar activity was lateralized to the right, as described in the literature. The data demonstrate the robustness of the language network topology across multiple languages in an individual subject.

**References**

1. Fedorenko E, Hsieh P-J, Nieto-Castañón A, et al. New Method for fMRI Investigations of Language: Defining ROIs Functionally in Individual Subjects. *J Neurophysiol* 2010;104:1177-94.
2. Luna LP, Sherbaf FG, Sair HI, et al. Can Preoperative Mapping with Functional MRI Reduce Morbidity in Brain Tumor Resection? A Systematic Review and Meta-Analysis of 68 Observational Studies. *Radiology* 2021;300:2047-23.
3. Malik-Moraleda S, Ayyash D, Gallée J, et al. An investigation across 45 languages and 12 language families reveals a universal language network. *Nat Neurosci* 2022;25:1014-9.