

Shared neural processing of grammar and arithmetic?

— Insights from a meta-analysis



7th Conference of the Mathematical Cognition and Learning Society

22nd June 2023

Nurit Viesel-Nordmeyer^{1,2,3} Johannes Ziegler³

& Jérôme Prado⁴



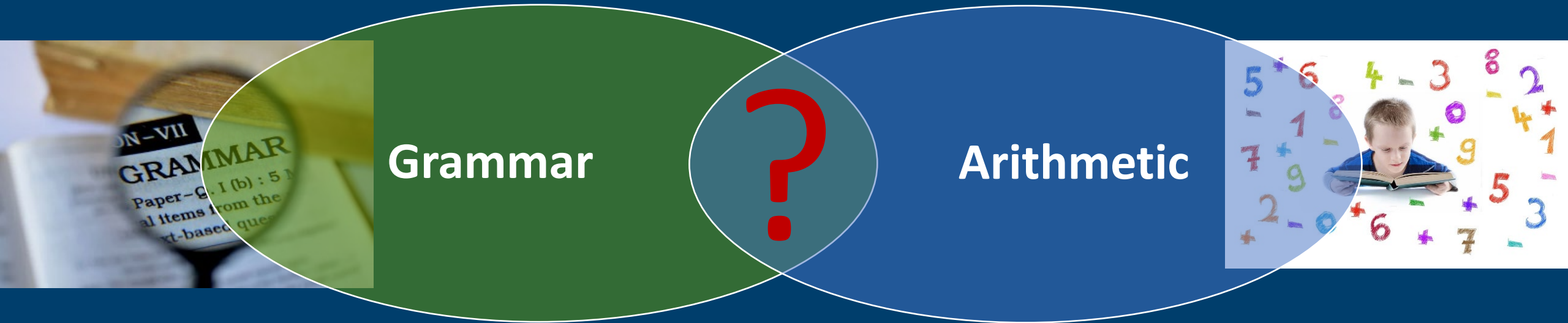
¹Pôle Pilote pour la Recherche en Education et la formation des enseignants (AMPIRIC), Aix-Marseille University, France

²Association Départementale Études et de Formation (ADEF), INSPE, Aix-Marseille University, France

³Center de Recherches en Psychologie et Neurosciences (CRPN), Aix-Marseille University, CNRS, France

⁴Centre de Recherche en Neurosciences de Lyon, CNRS, INSERM, & Université de Lyon, France

Problem outline



Relation between (impaired) processing

e.g., Chow et al., 2021; Kleemans et al., 2018;
Viesel-Nordmeyer et al., 2019; 2021; Wimmer et al., 2024

Problem outline

rules?
regularities?

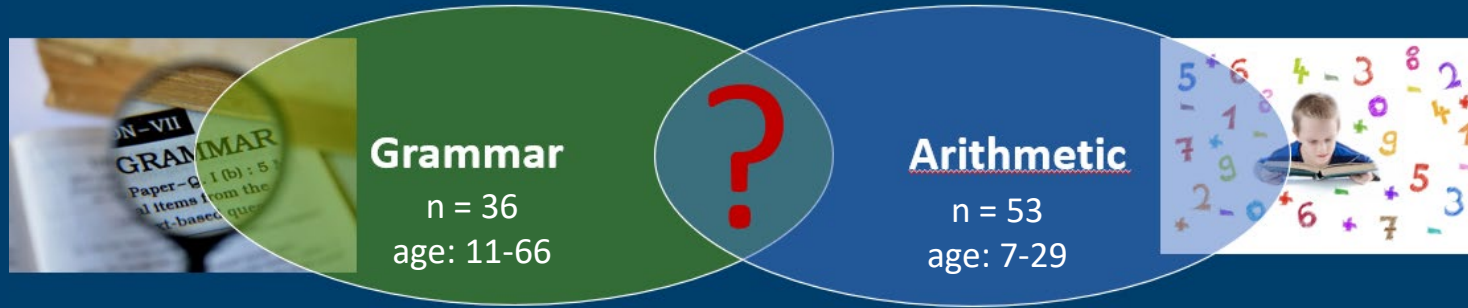
Grammar

Arithmetic

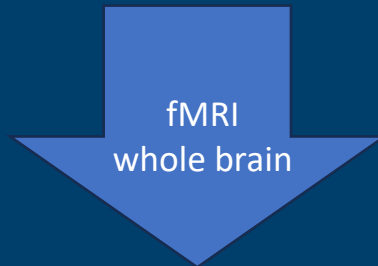
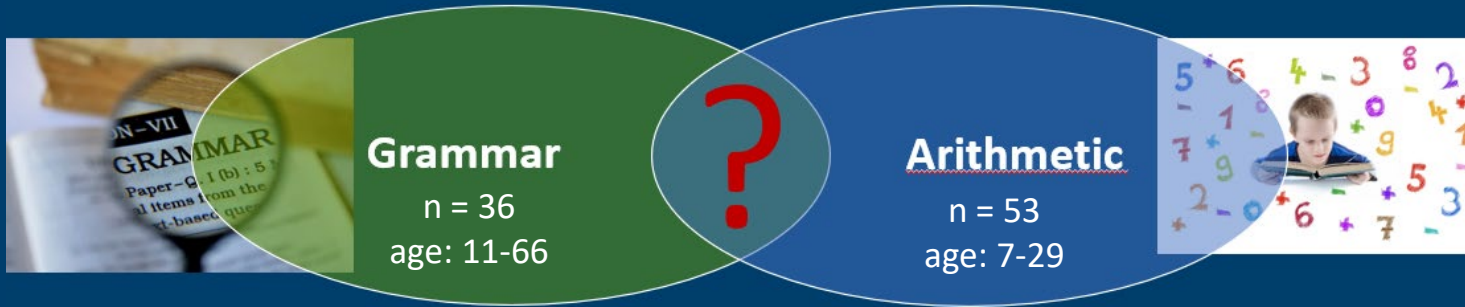
Relation between (impaired) processing

e.g., Chow et al., 2021; Kleemans et al., 2018;
Viesel-Nordmeyer et al., 2019; 2021; Wimmer et al., 2024

Problem outline



Problem outline



ALE
Meta-Analysis

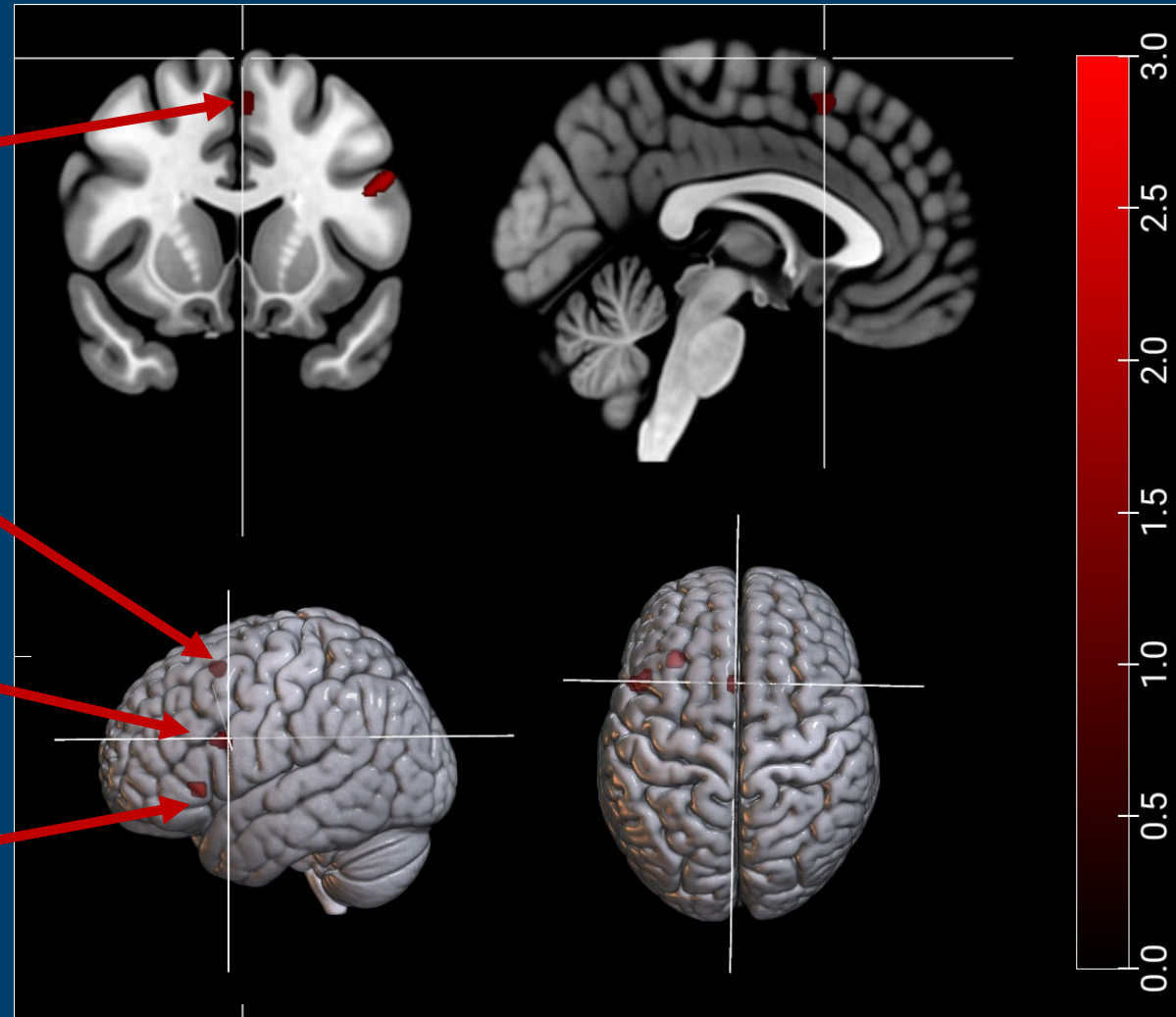
e.g., Eickhoff et al., 2012

Results: Overlap between grammar and arithmetic processing

1. Left Supplementary Motor Area (BA6)

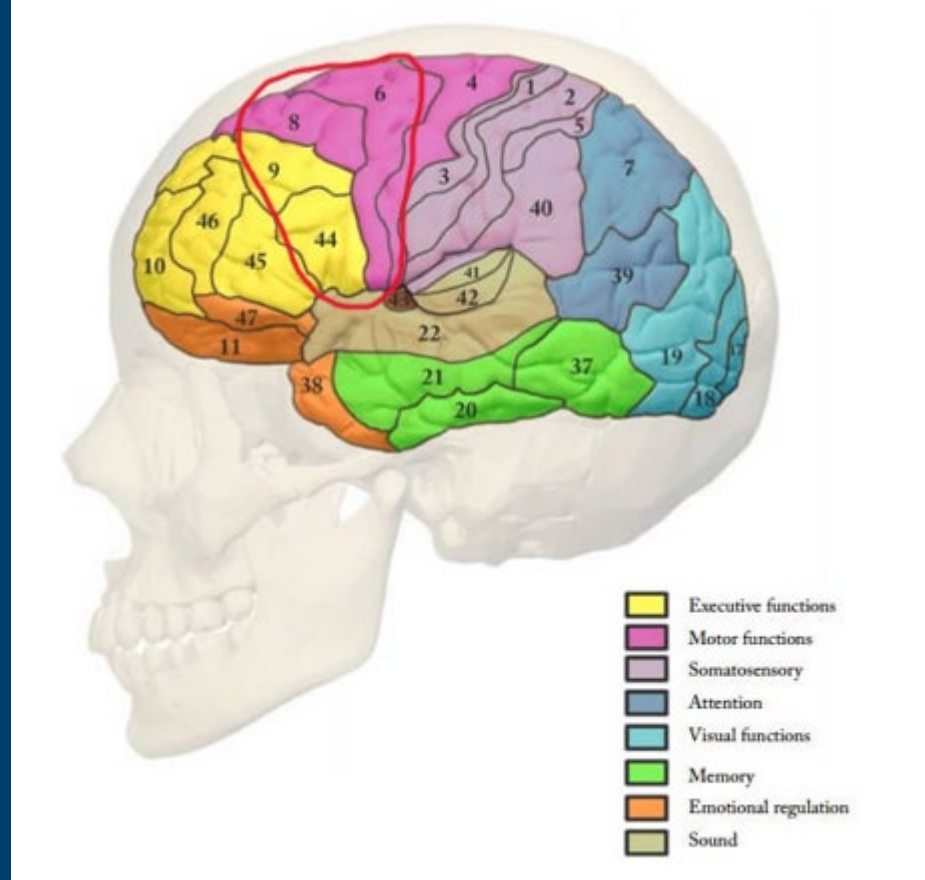
2. Left Dorsal Inferior Frontal Gyrus (BA9)

3. Left Insula (BA13)

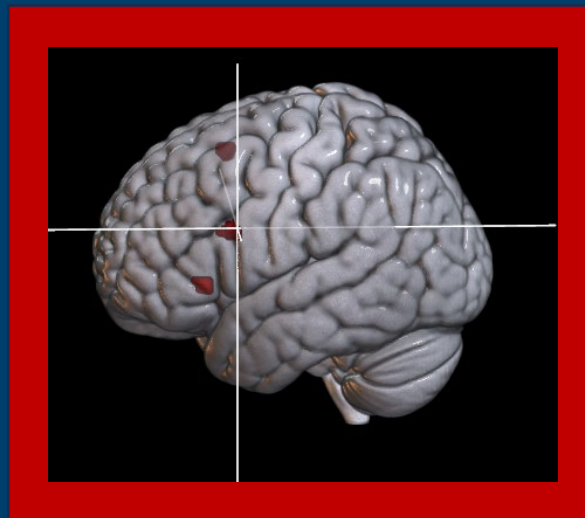


Notes. Conjunction analysis of arithmetic and grammar processing including 21 studies (Arithmetic: N = 13; Grammar: N = 8); Voxel-level FWE of 0.05, 1000 Permutations, and 200mm³ volume

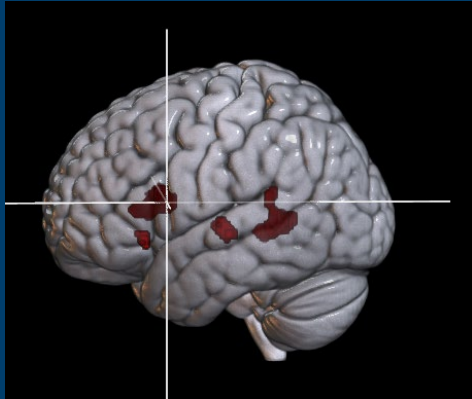
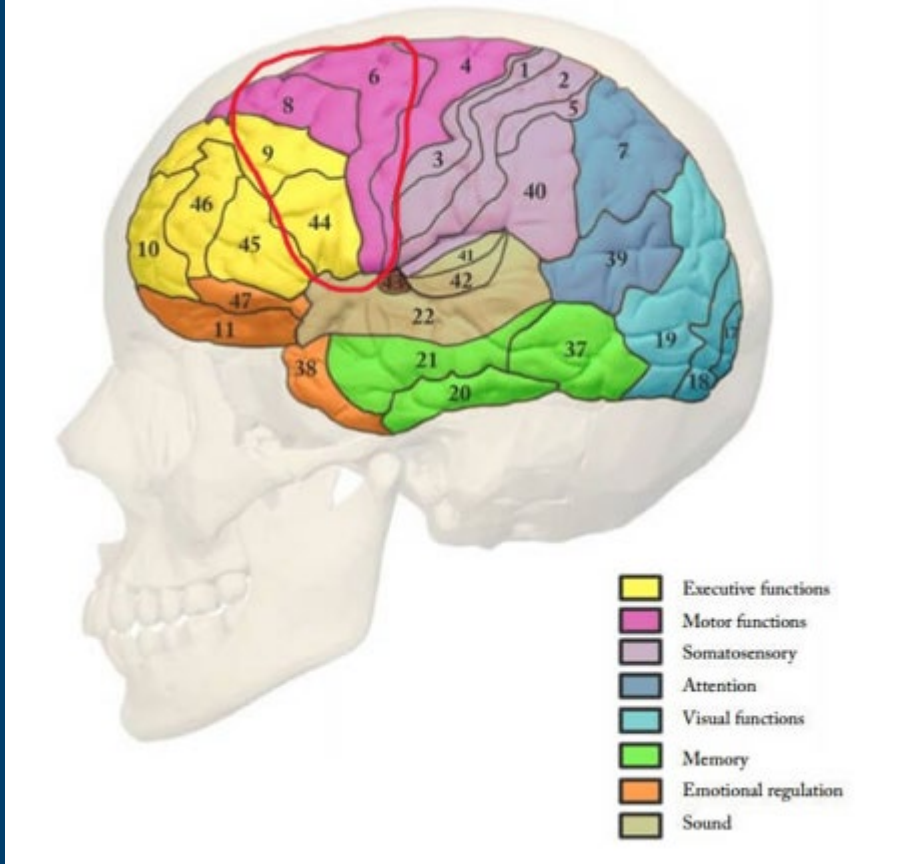
Results



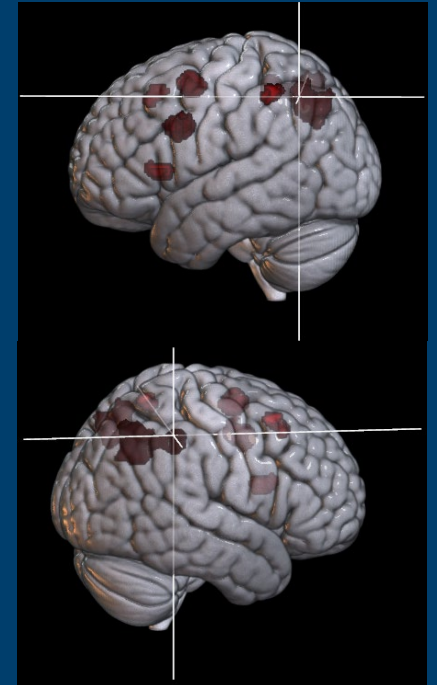
Grammar
&
Arithmetic



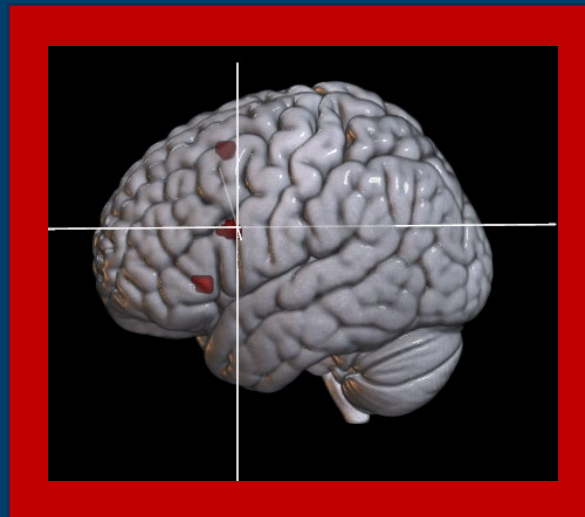
Results



Grammar vs. Arithmetic



Arithmetic vs. Grammar

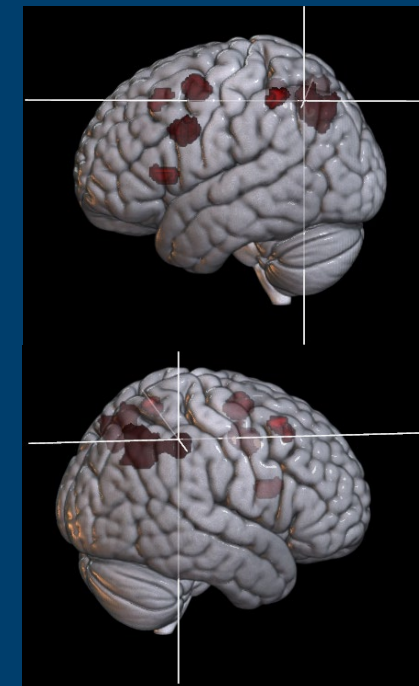
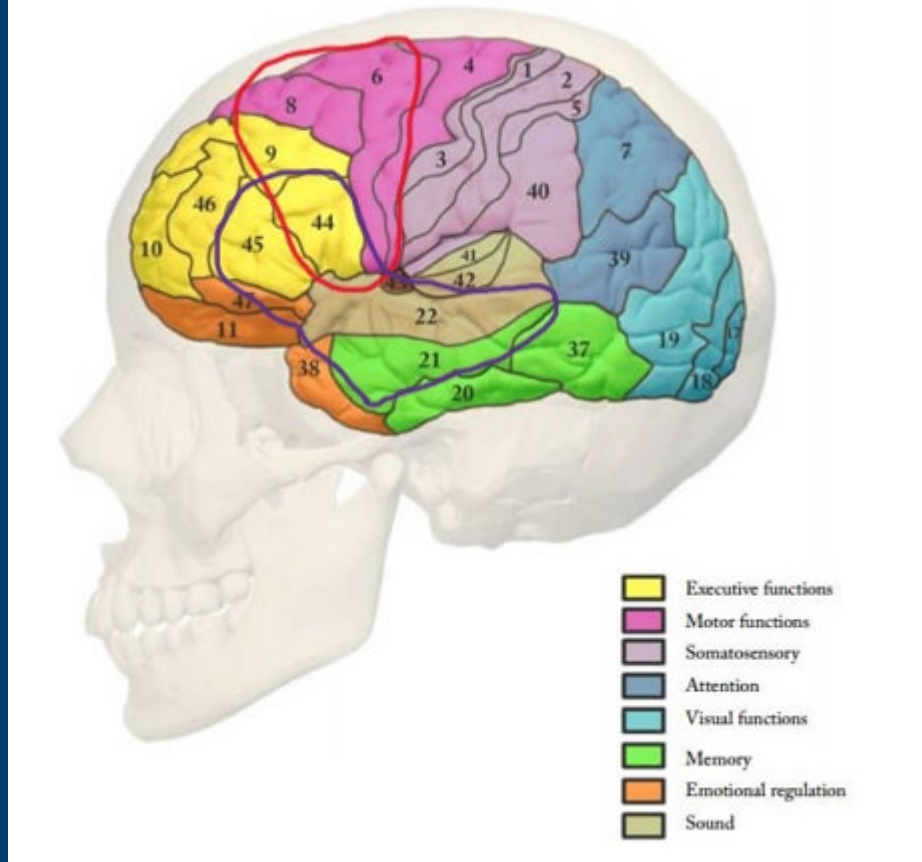
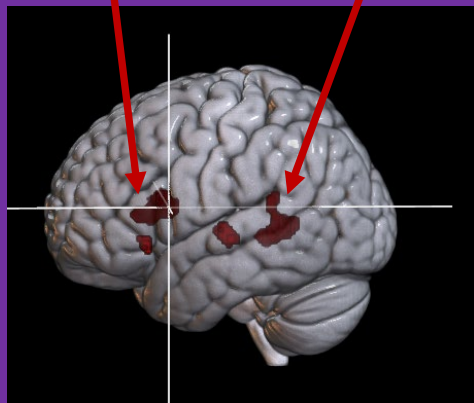


Grammar
&
Arithmetic

Results

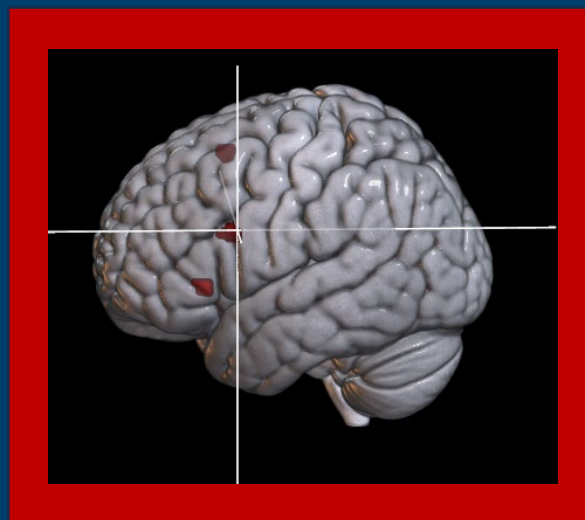
Left IFG

Left MTG



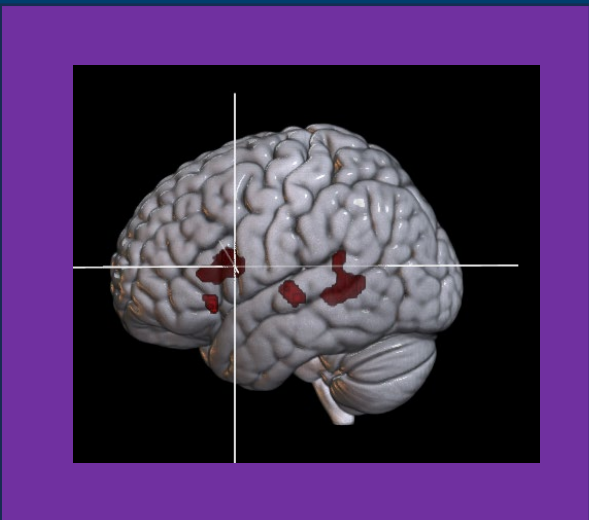
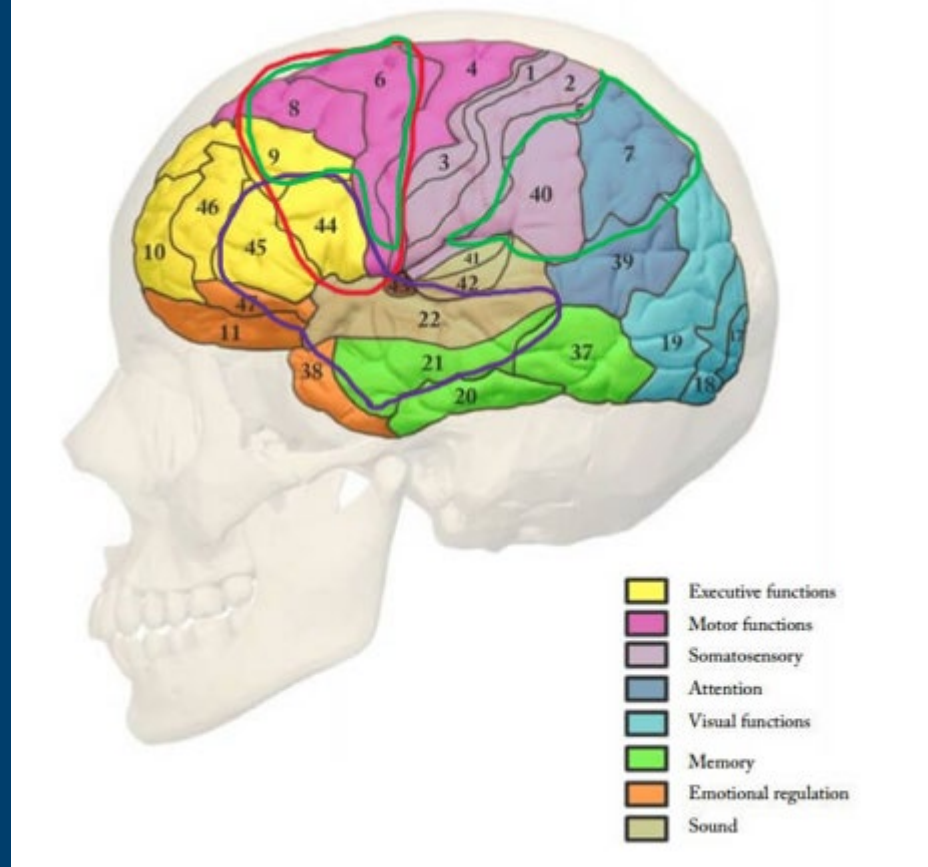
Grammar vs. Arithmetic

Grammar
&
Arithmetic

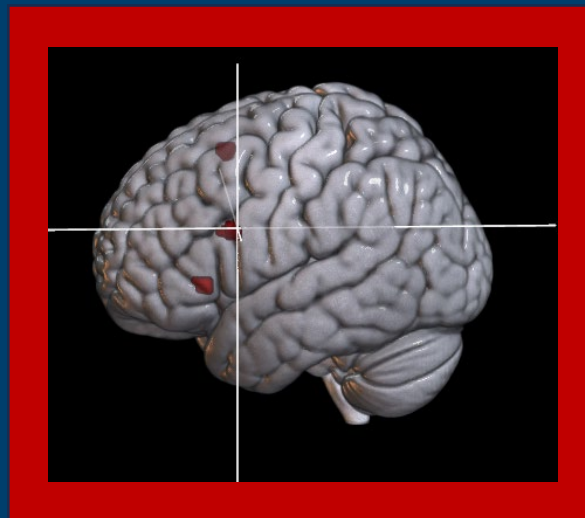


Arithmetic vs. Grammar

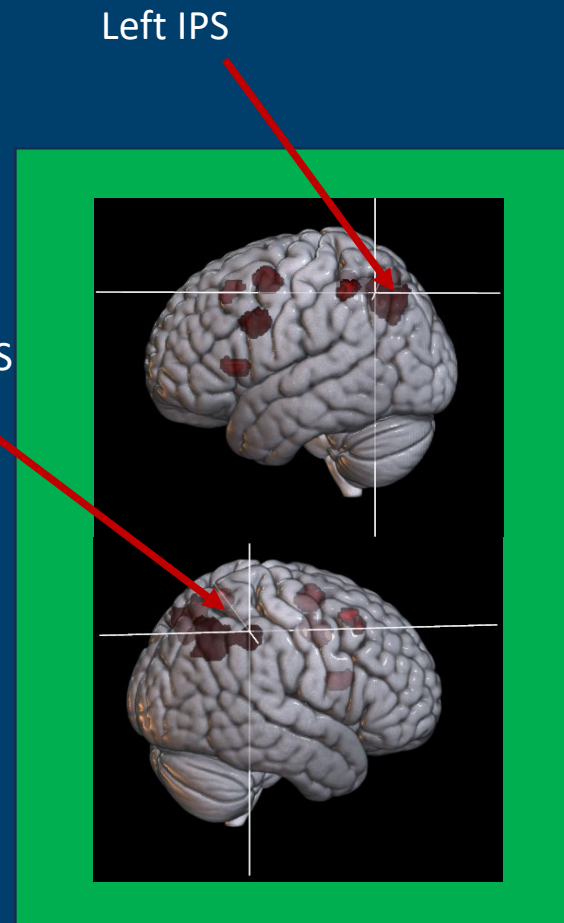
Results



Grammar vs. Arithmetic



Grammar & Arithmetic



Arithmetic vs. Grammar

Discussion – Overlap grammar and arithmetic

Overlap

→ **Multiple demand network** (e.g., review: Fedorentko et al., 2024)

→ **Executive demand** (e.g., meta-analysis: Nee et al., 2012)

→ “hierarchical dependencies, regardless of modality and use”
(e.g., Fadiga et al., 2009)

→ “grammar network” (Sakai et al., 2005)



+ evidence of **domain separate mechanisms** of arithmetic and grammar processing

Future Studies/Limitations

→ studies on separate age groups

→ contrasting

- grammar processing
- arithmetic processing
- working memory processing

→ visual and auditive testing

Thank you for your attention!



PhD Nurit
Viesel-Nordmeyer



PhD Johannes
Ziegler



PhD Jérôme
Prado



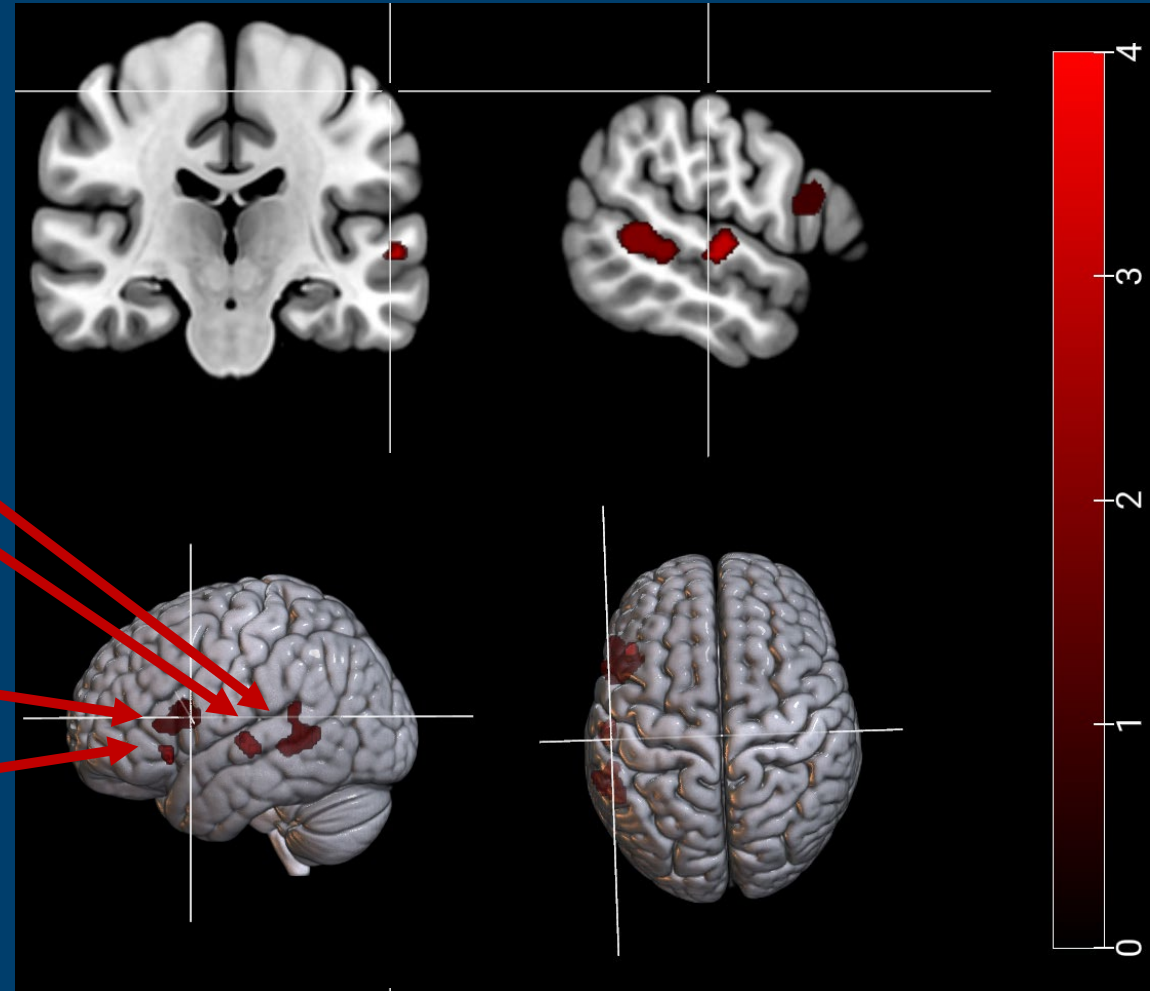
Results: Grammar processing vs. Arithmetic processing

2. Left Middle/Superior Temporal Gyrus
(BA22,BA21)

3. Left Superior Temporal Gyrus
(BA22)

1. Left Inferior Frontal Gyrus
(BA44,BA45)

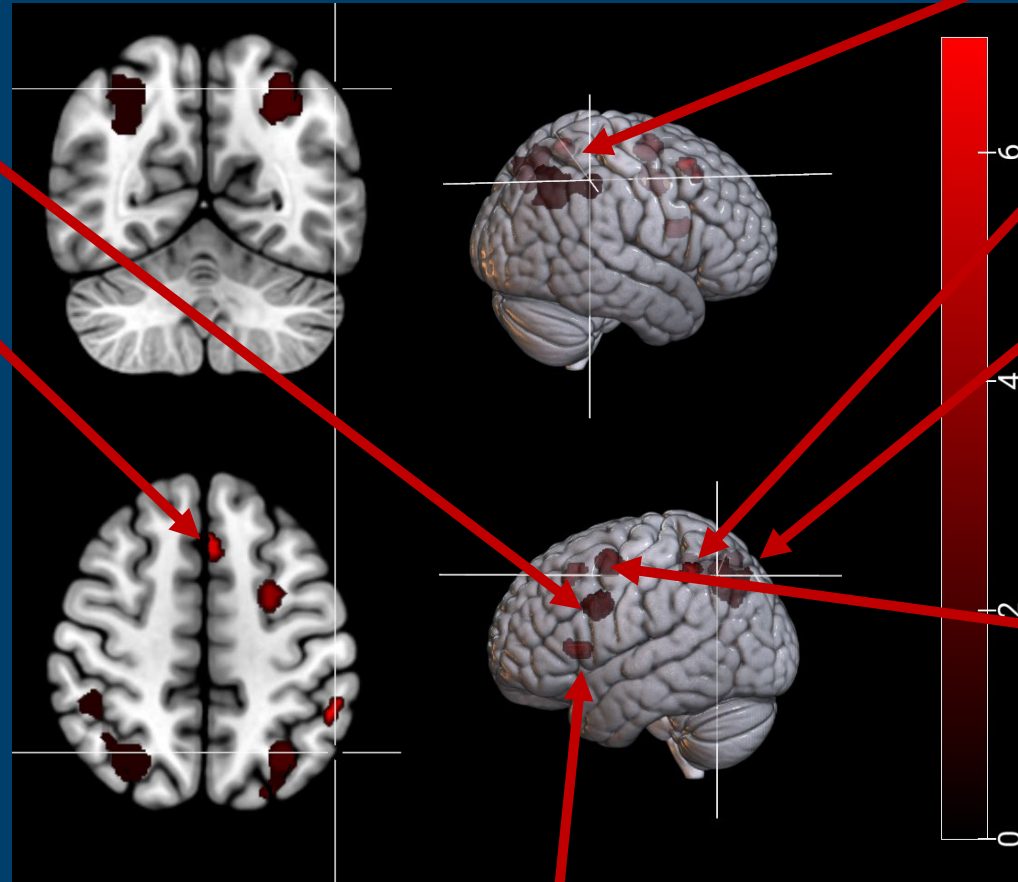
4. Left Inferior Frontal Gyrus (BA47)



Results: Arithmetic processing vs. Grammar processing

3. Left Dorsal Inferior Frontal Gyrus/ Precentral Gyrus (BA6; BA9)

6. Left Supplementary Motor Area (BA6)



1. Right IPS (BA7; BA40)

7. Left IPS (BA6; BA40)

2. Left IPS (BA7; BA31)

4. Left Middle Frontal Gyrus (BA6)

5. Left Insula (BA13)