

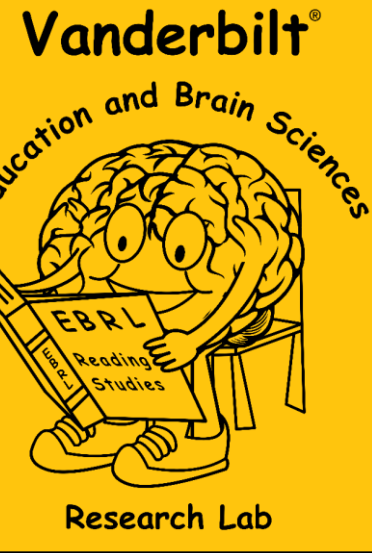
Specificity of the VWFA and the IPS: A Meta-Analysis of Atypical Reading and Math

Amanda Martinez-Lincoln¹, Laurie E. Cutting^{1,2}, Gavin R. Price^{1,2}, and Laura A. Barquero¹



VANDERBILT UNIVERSITY

¹Vanderbilt University, ²Vanderbilt University Medical Center

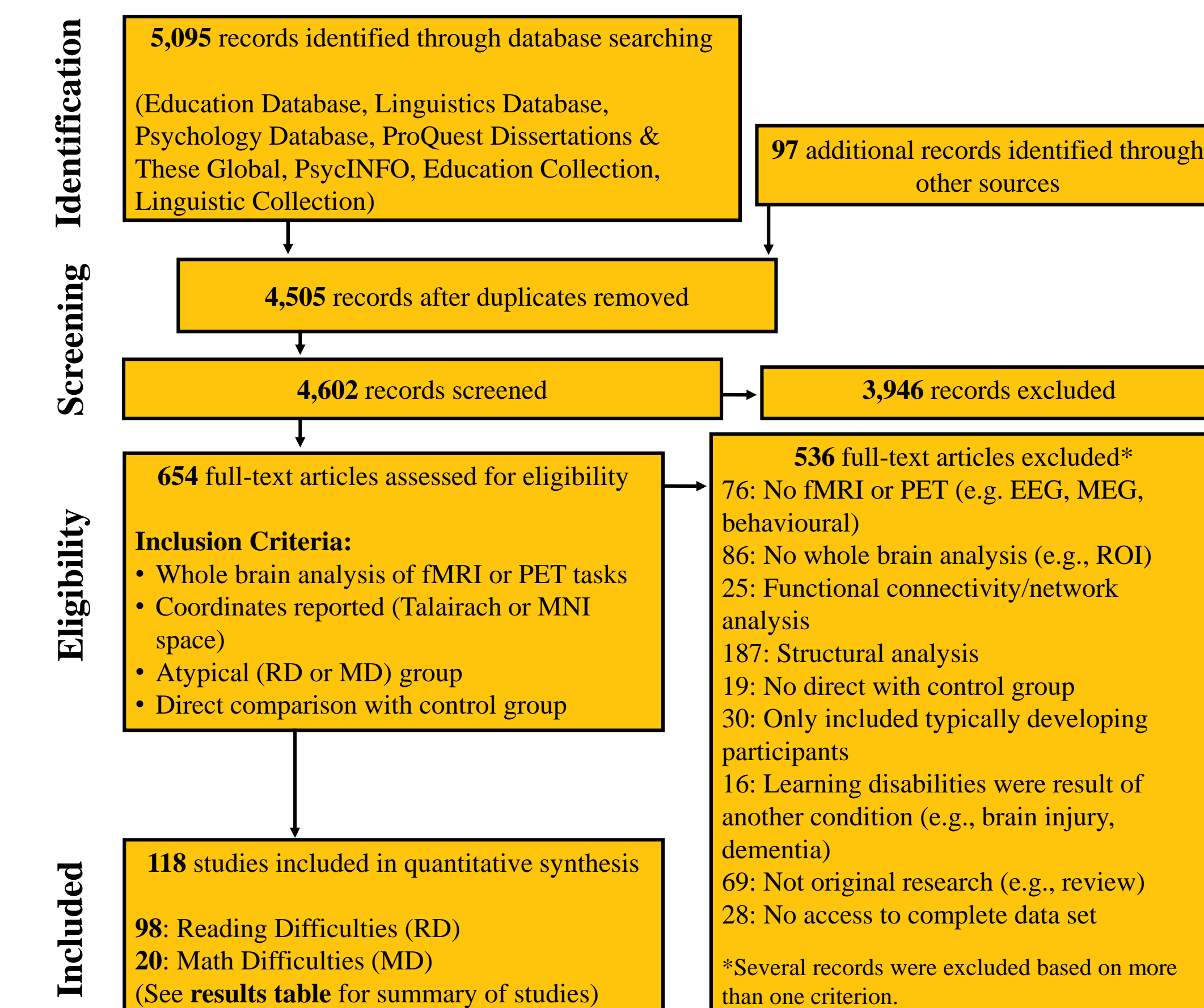


Background

- The literature largely supports the specificity of the Visual Word Form Area (VWFA) to proficiently identify words during reading (e.g., Cohen et al., 2000) and the Intraparietal Sulcus (IPS) to adequately process numbers during math (e.g., Arsalidou & Taylor, 2011).
- Yet, it remains unclear whether these areas play a role across other types of tasks in individuals with learning difficulties, and the extent to which the VWFA and the IPS anomalies are specific to reading difficulties (RD) vs. math difficulties (MD), respectively.

Study Aim: Identify consistencies across studies regarding the functional specificity of VWFA and the IPS for individuals with RD and individuals with MD, compared to typically developing individuals (TD).

Methods

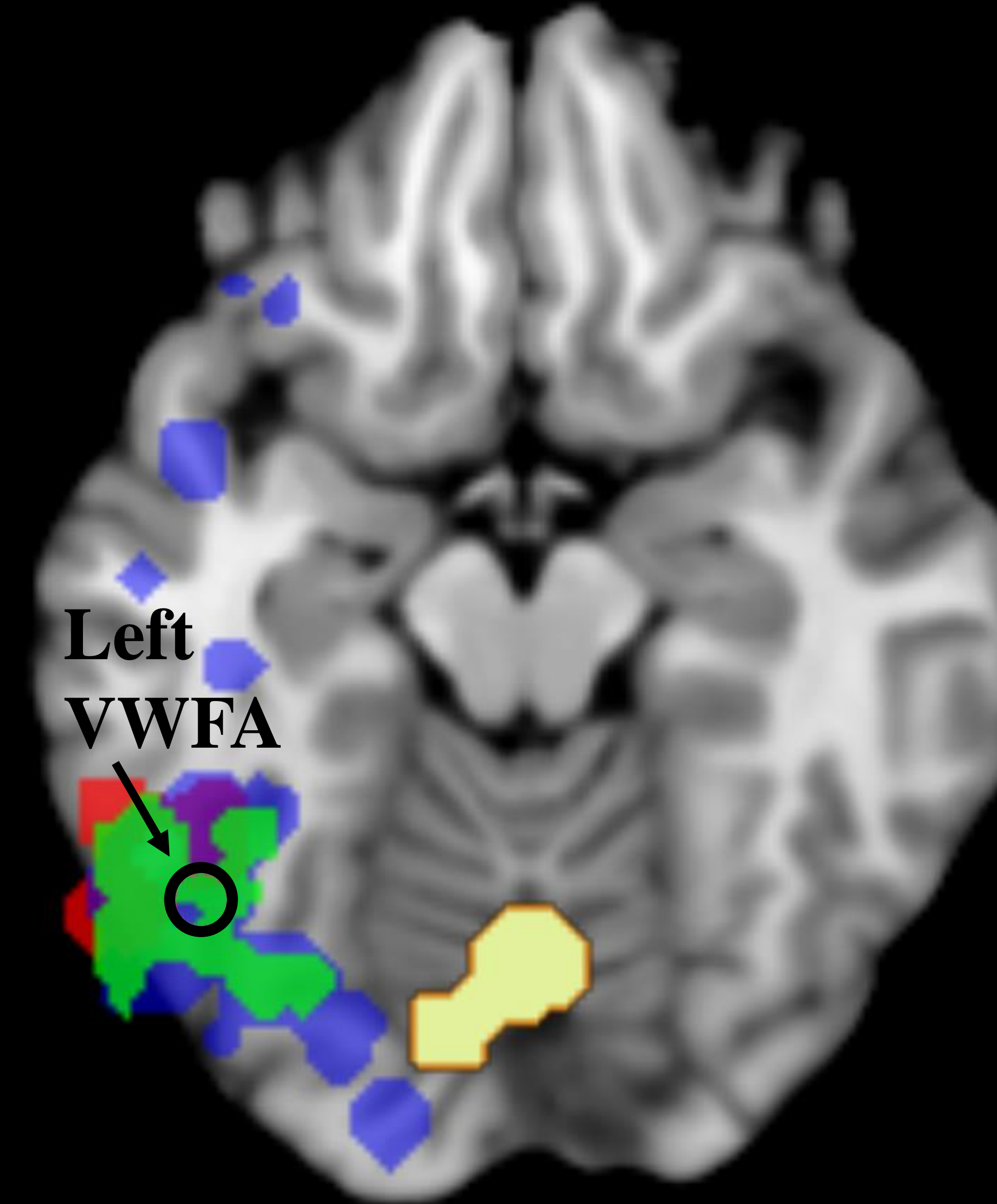


- Coordinates that directly compared TD with RD or MD were entered into GingerALE. An activation likelihood estimate (ALE) meta-analysis was conducted to examine the specificity of the VWFA and the IPS across studies (FWE $p < .05$).
- The VWFA was defined as a sphere centered at ($x = -44, y = -58, z = -15$) with a radius equal to 5mm (Jobard et al., 2003; Vigneau et al., 2005).
- The IPS was defined as a sphere centered at ($x = 36, y = -48, z = 48$) with a radius equal to 5mm (Sokolowski et al., 2017).

Under Activation of left VWFA for RD and MD

TD > RD
 Reading Tasks
 ($k = 19, N = 649, foci = 198$)
 Language Tasks
 ($k = 51, N = 1,750, foci = 494$)
 Other Tasks
 ($k = 13, N = 386, foci = 61$)

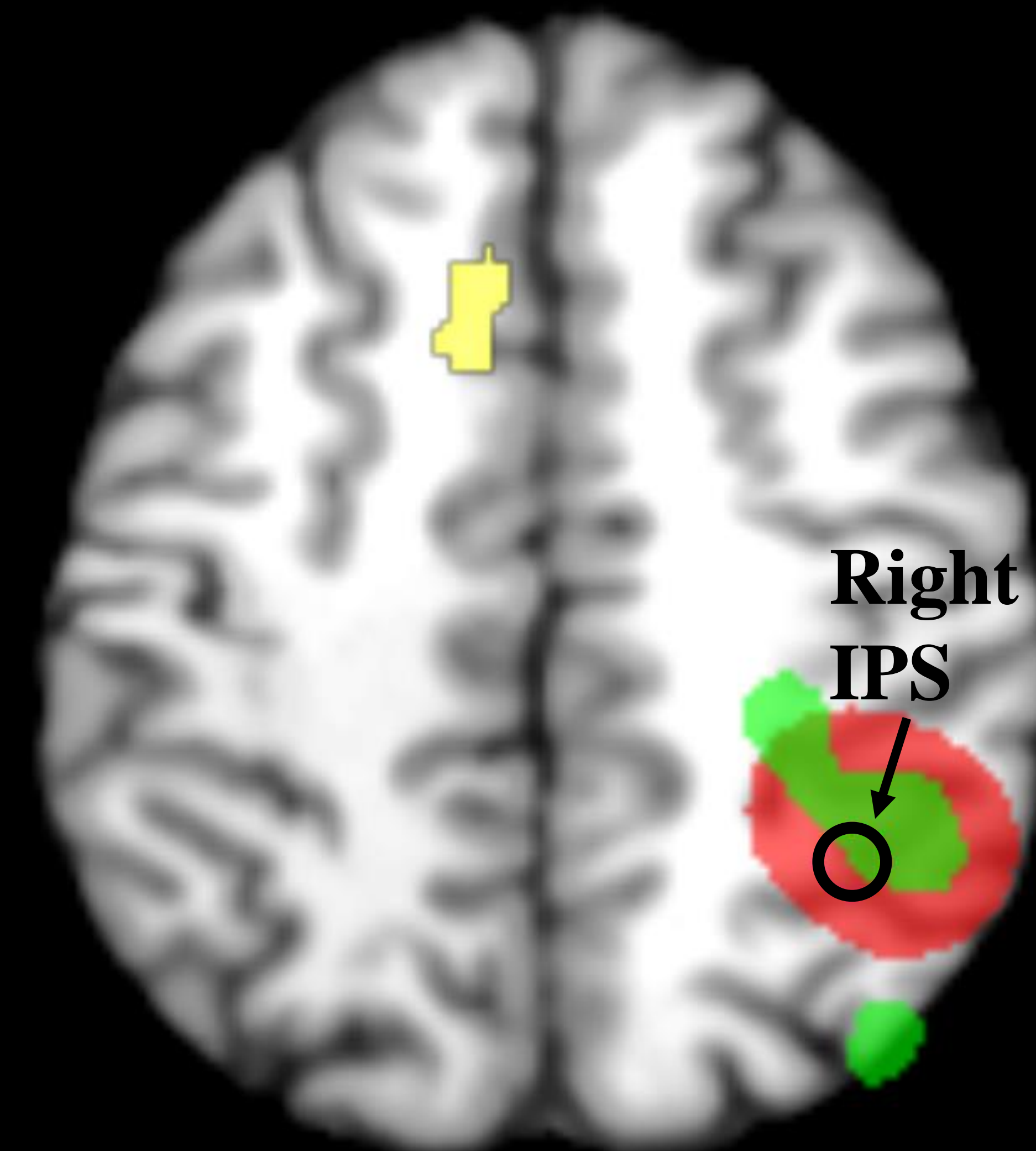
TD > MD
 All Tasks
 ($k = 9, N = 264, foci = 18$)



Overactivation of Right IPS for RD and MD

MD > TD
 Math Tasks
 ($k = 15, N = 542, foci = 126$)
 Other Tasks
 ($k = 4, N = 117, foci = 6$)

RD > TD
 All Tasks
 ($k = 54, N = 1,919, foci = 423$)



Note: VWFA = Visual Word Form Area; IPS = Intraparietal Sulcus; RD = Reading Difficulties; MD = Math Difficulties; TD = typically developing individuals; k = number of studies included in analysis; N = number of participants included in analysis.

Results

Summary of Studies ($N = 118$)				
Characteristic	Reading Difficulties ($N = 98$)		Math Difficulties ($N = 20$)	
	n	%	n	%
Age Level ^a				
Elementary students	47	38.21	15	71.43
Middle school students	28	22.76	2	9.52
High school students	11	8.94	0	0.00
Adults	37	30.08	4	19.05
Types of Tasks ^a				
Reading	19	17.43	0	0.00
Language	67	61.15	0	0.00
Math	1	0.98	17	77.27
Working Memory	5	4.90	2	9.09
Other	17	16.67	3	13.64

Note. ^a Several studies included more than one category.

Visual Word Form Area (top center image)

- Under activation of the left VWFA was corroborated in studies that examined children and adults with RD as they completed reading tasks, oral language tasks (e.g., picture naming), and other types of tasks (e.g., passive visual motion, motion detection).
- Activation of VWFA was not present for those with MD.

Intraparietal Sulcus (bottom center image)

- Overactivation in the right IPS was demonstrated in studies that examined children with MD in math tasks (e.g., math facts, calculation, magnitude comparison) and other types of tasks (e.g., spatial working memory, reasoning).
- Activation of IPS was not present for those with RD.

Discussion

- Preliminary results indicate that though the functional activation of the VWFA and the IPS are broadly anomalous for task types, the left VWFA was specific to those with RD and activation of the right IPS was specific to those with MD.
- These findings suggest that the left VWFA and right IPS may be distinctive to an underlying deficits in either reading or math, rather than being exclusive for type of task.

Acknowledgements

This work was supported in part by NIH/NICHD R37 HD095519, NIH/NICHD R01 HD044073, NIH/NICHD U54 HD083211, and resources of Vanderbilt REDCap and the Advanced Computing Center for Research and Education (ACCRe) at Vanderbilt University.