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

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Introduction: The literature largely supports the specificity of the Visual Word Form Area (VWFA) to proficiently identify words during reading [e.g., 1] and the Intraparietal Sulcus (IPS) to adequately process numbers during math [e.g., 2]. Yet, it remains unclear whether these areas play a role across other types of tasks in individuals with learning difficulties. The purpose of this study is to identify consistencies across studies regarding the functional specificity of VWFA for individuals with reading disabilities (RD) and the IPS for individuals with math disabilities (MD), compared to typically developing individuals (TD).

Methods: A systematic search of the literature identified 4,505 research items. Items were hand-sorted, using article titles. 557 items were then closely read to determine eligibility, employing the following criteria: 1) represented original research; 2) included at least one measure of functional whole brain imaging; and 3) included at least one group of participants identified with RD or MD. A hand search was also conducted. This process yielded 118 studies that were double coded. Coordinates that directly compared TD with RD or MD were entered into GingerALE (Brainmap.org). An activation likelihood estimate (ALE) meta-analysis was conducted to examine the specificity of the VWFA and the IPS across studies. The VWFA was defined as a sphere centered at ($x = -44$, $y = -58$, $z = -15$) with a radius equal to 5mm [3, 4]. The IPS was defined as a sphere ($x = 36$, $y = -48$, $z = 48$) with a radius equal to 5mm [5]. Imaging results are reported using a family wise error (FWE) correction of $p < .05$.

Results: Overall, under activation of the VWFA was corroborated in studies that examined children and adults with RD across reading tasks, oral language tasks, and other types of tasks (i.e., passive visual motion, motion detection). Overactivation of the IPS was demonstrated in studies that examined children with MD across math tasks (e.g., math facts, calculation, magnitude comparison) and other types of tasks (spatial working memory, reasoning).

Discussion: Preliminary results indicate that VWFA functional activation was not specific to reading tasks for RD, and the IPS was not exclusive to math tasks for MD. Instead, the VWFA exhibited under activation across oral language and motion-related tasks in children and adults with RD. For children with MD, over activation of the IPS was also displayed in working memory and reasoning tasks. These findings suggest that the functional specificities of the VWFA and the IPS are broad for individuals with learning disabilities.

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