Structural Brain Differences in Good and Poor Comprehenders Identified through a Regression-Based Quantitative Method

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Specific Reading Comprehension Disorder (S-RCD) is characterized by poor reading comprehension despite intact decoding ability (for review see Landi & Ryherd, 2017). Despite years of study, there is no established, standardized method of classifying individuals with S-RCD. Most studies use a cutoff-based classification approach in which S-RCD participants exhibit a discrepancy between their decoding and reading comprehension abilities: that is, they achieve a standard reading comprehension score below some criterion, coupled with standard decoding performance that meets or exceeds an age-appropriate norm. However, because this approach relies on dichotomizing continuous variables, individuals with quantitatively similar scores (i.e., scores close to the cutoff criterion) are treated as qualitatively different; this practice is also associated with statistical problems like distorted effect sizes, reduced power, and increased Type 1 error (MacCallum et al., 2002). To address these weaknesses, some researchers have adopted a regression-based method to identify groups of readers differing on comprehension ability, but not on subcomponent measures (e.g., Tong et al., 2011, 2013). Specifically, reading comprehension ability is predicted from component skills such as nonverbal IQ, decoding ability, and vocabulary knowledge. Readers are classified as S-RCD if their comprehension scores are much lower than their predicted scores; typically developing (TD) if comprehension is commensurate with model predictions; and unexpected good comprehenders (UGC) if their comprehension scores are much higher than predicted. This approach tailors group selection criteria to the individual by comparing reading comprehension skill to a predicted value based upon the individual’s known cognitive abilities, rather than relying on population norms. Despite these advantages, this method has not been used in any neurobiological investigations of S-RCD. Further, only one study of brain structure has considered S-RCD, revealing reduced gray matter volume (GMV) in prefrontal cortex for S-RCD relative to TD, consistent with previous findings of impaired executive function in this population (Bailey et al., 2016).

This investigation is the first to use the regression-based group classification method to investigate the relationship between comprehension skill and brain structure. In this study, we assessed cortical structural differences between three comprehension groups (S-RCD, TD, UGC) derived according to the regression-based quantitative method. We predicted reading comprehension scores using age, decoding ability, nonverbal IQ and vocabulary. TD readers' comprehension scores fell within the 15% CI around the regression line. S-RCD readers had scores below the lower 65% CI of the regression line, while UGC readers' scores were above the upper 65% CI. From an original sample of 172 participants (ages 13-24), this method identified 20 TD, 22 S-RCD, and 25 UGC. Exploratory whole-brain analysis of GMV revealed group differences, in which TD readers showed reduced GMV relative to UGCs in the left superior parietal lobule (SPL), which has been functionally implicated in improved comprehension ability following remedial instruction (Meyler et al., 2008). Our findings highlight the importance of studying UGCs (who, like S-RCD readers, have discrepant comprehension and decoding profiles) in addition to TD and S-RCD readers to gain a broader perspective on how brain structure may relate to reading comprehension skill profiles.