A Novel Approach to Improving Reading Fluency

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Improving processing speed to help struggling students read more efficiently

Until the recent past, educational practice has focused on teaching struggling readers the rules of how sounds and symbols go together. These phonologically focused interventions have been shown to be highly effective in teaching students to accurately read words (Wolf et al., 2002). The Orton-Gillingham approach, for example, leads to notable improvements on language assessments such as "word decoding" and "non-word decoding," which evaluate a child's ability to apply their letter-sound rules. However, after receiving this training, students are still often considered dysfluent due to slow reading speed (Norton & Wolf, 2012; Wolf & Bowers,1999). Such slow and laborious reading is especially burdensome for reading the increasingly larger and more complex texts after early elementary school.

There are now, however, evidence-based instructional methods that are known to enhance overall reading fluency. The novel instructional approach described below was inspired by evidence that struggling readers often exhibit this second difficulty related to reading, reduced fluency, not only for words, but even for naming objects and colors (Wolf & Bowers,1999).

Naming speed is known to be a strong predictor for those at risk for dyslexia and is a deficit in over 60% of children with reading disabilities (Geschwind, 1974; Norton & Wolf, 2012; Wolf, Bowers, & Biddle, 2000). Furthermore, it is naming speed that most closely correlates with word and connected-text reading fluency (Wolf & Bowers, 1999). This reduced speed of processing in dyslexia is not limited to text. A large body of multi-disciplinary research has established that individuals with dyslexia are not only slower in identifying language-related stimuli, but are also slower in many cognitive measures in the auditory, visual and motor domains (Bexkens, van den Wildenberg, & Tijms, 2015), & Tijms, 2015; Daucourt, Schatschneider, Connor, Al Otaiba, & Hart, 2018; Mugnaini et al., 2009; Wolf et al., 2000; Mugnaini et al., 2009; Wolf et al., 2000).

The observation that reading difficulty is often associated with a broad slowness on cognitive tasks raises the possibility that fostering better speed for non-linguistic material may lead to increased reading fluency. Here we report promising results from a controlled study, suggesting that reading speed may be better remediated by a combined approach targeting both non-language cognitive capacities and reading skills.

Exploring the link between executive function, processing speed, and word reading: the Stroop task

Children with dyslexia frequently have trouble with a common measure of executive function: the Stroop task (Protopapas, Archonti, & Skaloumbakas, 2007). The traditional Stroop task involves the words: red, yellow, blue, and green, which are written in colored fonts. Students

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must name the color of the font rather than the word, inhibiting the tendency to read the text and instead answering "red" when presented with the word "yellow". Our work with more than 400 Carroll students over 5 years has revealed the problems with the Stroop test are a common cognitive struggle of our students, with about ⅔ of them showing a weakness. Furthermore, slow response times on the Stroop test identify students who are likely to struggle with reading speed. Taken together these observations suggest that for students with slow Stroop reaction time, slow reading speed may be a consequence of weak executive function. Below we show that the reading speed of children with slow Stroop reaction times can be improved by cognitive training.

At Carroll, a controlled study using a Response Time Training Program (RTT) investigated the use of a non-reading visual judgment training to improve specific executive function and word-level reading skills

Taking into account the close relationship between the cognitive measure of reaction time and the language components of fluency, we developed a novel processing speed intervention called the Response Time Training program (RTT). The program includes games that require quick and purposeful responses. By strengthening the student's general reaction time abilities, we hoped to strengthen the brain network involved in fluent reading and produce improvements in language-related, timed tasks.

Of 242 Carroll 5-7th grade students in this study more than half have a relative weakness in word reading fluency (standard score less than 90 on the TOWR-E). Computer-based "brain training" programs have skyrocketed in popularity over the last few years, although few have been targeted specifically to individuals with learning disabilities (Diamond & Ling, 2016). Most studies of cognitive training have focused on working memory, while here we choose to target complex reaction time because it is more closely related to reading speed than working memory. Following this logic, we selected 80 students with slow Stroop reaction time for our novel processing speed intervention. The remaining 104 other students received another, non-reaction time focused computer training program.

The RTT intervention program includes 6 core activities selected from commercially available computer games. All of the chosen games are timed and not directly related to language skills. Each game requires completing a complex response task such as hitting a specific mole on the head before it disappears or having a motorcyclist rapidly change lanes to avoid oncoming road obstacles. During intervention periods, the students engage in approximately 30 minutes of game play, 3 days a week, for 10 weeks. Half of the 90 students chosen to receive reaction time training completed the games in the fall semester, while the other half received the training in the spring. Using this crossover design we can compare each students' growth in cognitive and reading skills over the interval during which the student received cognitive training to growth during an equivalent period of academic instruction without RTT training.

Training cognitive skills enhanced fluency in reading

As hypothesized, after periods of training with a non-language reaction time intervention, there is an improvement in tasks requiring reading that was not seen during the control periods without RTT. During the intervention period, students improved significantly more than the control period (5 standard scale points) in Stroop reaction times ($p<0.05$). There was no significant improvement for Stroop reaction time during control periods, suggesting the increase was highly likely to be a result of the intervention program. Carroll School students are assessed on reading skills once a year in May. While these annual assessments do not allow us to isolate the contribution of RTT to reading fluency improvement compared to the combined

impact of multiple types of teaching, students' outcomes are encouraging. Students who received the RTT program had about 20% faster growth in word reading fluency than peers who received similar duration and intensity cognitive programs targeting working memory. Consistent with the possibility that RTT is the cause of this accelerated reading skill development, larger gains in Stroop reaction time during the intervention period are correlated positively with gains in single word reading fluency on the TOWRE (test of word reading efficiency). Taken together these data suggest that by improving Stroop reaction time, word reading speed can be increased. The next phase of our research work will include measures of sight-word reading aligned with intervention and control periods to confirm that these differences are due to cognitive training to conclusively evaluate whether RTT in combination with excellent reading instruction leads to more rapid reading acquisition.

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