BRINGING RESEARCH INTO PRACTICE

The Brain Basis of Fluency Development: Implications for Assessment and Instruction

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This article discusses how reading develops in the brain in order to provide a deeper understanding of dysfluent reading with links to the assessment and instruction techniques that are most likely to benefit dyslexic readers.

The past thirty years brought an unprecedented rise in the recognition of fluency as a crucial goal of reading instruction. In 1998 the National Research Council recommended that fluency be monitored as an indicator of problems with reading comprehension (Snow, Burns, & Griffin, 1998). The National Reading Panel (2000) named reading fluency as one of the five components of good reading instruction. Since that time, stopwatches have become part of the arsenal in the fight for skilled reading.

Has the focus on text reading fluency drawn attention away from the foundation skills that support our quest to read for meaning? Stopwatches and charting can have an unintended consequence of motivating students to read faster than their optimum pace, which is the pace that allows for the accurate word recognition and appropriate intonation that indicates understanding. Today it is common to find children who rush through text, reading with *forced speed*. They sound monotone even when reading text written at their independent reading level. What should educators be teaching that will result in improved fluency and comprehension without inadvertently encouraging children to read at a forced speed?

Understanding the cognition and neuroscience behind fluent reading can help guide the way. Psychological research indicates that the speed and accuracy of single word reading is the main determiner of text reading fluency. Unfortunately, this conclusion is often rolled out to support curricula that emphasize reading speed (the product of skilled word recognition) over accuracy (the process by which unfamiliar words become familiar). Developmentalists like Linnea Ehri and Jeanne Chall have long recognized that word reading accuracy precedes word reading speed. Chall's *Learning to Read* phase explicitly places reading accuracy as a precursor to reading fluency. Take a moment to reflect on your own experience with learning to shoot a basketball, knit, or cook. When humans learn any new procedural skill (like reading), we are accurate before we are automatic.

OG educators focus on accuracy in order to help students acquire the tools to read new words independently. At first, decoding is slow and inaccurate. Brain connections are inefficient and imperfect. Practice helps to prune inaccurate connections and strengthen connections between neurons that fire together, making word recognition accurate. Every word read accurately represents one correct iteration of the reading network. With each iteration, the pathway is reinforced. Reading the same word accurately many times increases processing efficiency until it sounds like the word is recognized instantly. The phrase "practice makes perfect" describes the result of strengthening a brain network through repetition.

Reading Development in the Brain

Brain research into how reading develops can illuminate why children need to gain accuracy first, then fluency. The word recognition network in the brain comprises two routes, which cooperate to identify letter strings as words (Harm & Seidenberg, 2004). The present evidence indicates a staggered pattern of development for these two routes in the reading network, where decoding (dorsal route) lays the foundation for orthographic processing (ventral route) later in reading development. The first route to correlate with reading skill is the dorsal, phonological route that connects the frontal speech production area (Broca's Area) to the temporo-parietal letter-sound association area (Pugh et al., 2001; Wandell & Yeatman, 2013). This phonological route correlates with reading achievement before age 10. It is forming when educators help children build phonemic awareness skills, then connect speech sounds to letter forms. The second route to correlate with reading skill is the ventral, orthographic route that connects speech production areas to a more posterior area (the Visual Word Form Area) at the junction of the occipital and temporal lobes. Activation in the VWFA correlates with reading achievement around age 10 on average (Shaywitz et al., 2002). Therefore, the VWFA appears to become tuned to print through years of reading experience (McCandliss & Noble, 2003).

The brain evidence for staggered development of the reading routes converges with the behavioral research about how word recognition develops (see Rayner, Pollatsek,

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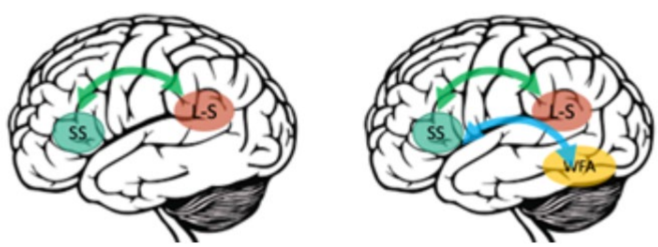
Ashby, & Clifton, 2012, p.280, for a review). Development of the dorsal, phonological route is consistent with behavior observed during Ehri's *Full Alphabetic* phase, in which children can sequentially decode words left-to-right. The act of sequential decoding, even when it is slow and labored, draws attention to all the sounds in a word and helps children form accurate memories for written words. These memories are reinforced every time a child reads or spells that same word again, and repeated exposures speed each subsequent reading of the word. OG practitioners build the efficiency of a child's sequential decoding skills through repeated practice reading decodable words in lists, spelling decodable words, and reading decodable texts. As we do so, we draw attention to the interior letters and how they map onto the sounds. This orthographic mapping process establishes clear, word-specific memories that are the foundation of fast word recognition (Kilpatrick, 2015).

Repeated practice with sequential decoding builds a consolidated, specific representation of each word (Ehri, 1999, 2002). After a certain number of accurate readings of a word, the child appears to recognize it automatically. Fast recognition of a familiar word is possible as readers develop a consolidated memory of its orthographic form. As reading experience grows and each word memory is consolidated, readers increasingly rely on the VWFA to read familiar words quickly (see Figure).

Figure: Development of the Reading Networks



On the left is the brain before age 10, when typical readers develop phonological processing along the green route that connects the speech sound area (SS) with the letter-sound association area (L-S). Activation in the L-S area predicts reading achievement in beginning readers. On the right is the brain after reading experience has tuned the word form area (WFA) to recognize familiar words instantly. Activation of the word form area predicts reading achievement from age 10 through adulthood.

Large tracts of axons known as *white matter tracts* connect the Speech Sound area (Broca's) and the Word Form Area (VWFA) to form a ventral route for word recognition in skilled readers. Magnetoencephalography (MEG) studies indicate activation of both areas within a fifth of a second of seeing a printed word (Pammer et al., 2004; Wheat et al., 2010). Through cooperative activation of phonology and orthography, skilled readers quickly recognize words during silent reading. When the reading networks coordinate efficiently, reading sounds fluent: it has the accuracy, rate, and intonation of speech.

Assessment to identify Dysfluency

Knowledgeable educators can use their expertise to differentiate among reading profiles and identify techniques for improving reading fluency. The most effective techniques will aim to boost the processes upon which fluency rests: phonemic awareness, decoding, accurate word recognition, and spelling.

There are many products that are designed to help educators document challenges in the above areas. There are tests of word level automaticity. There are tests that measure reading fluency orally and silently. The selection of a particular test or tests, though, can only be made with an understanding of what each test purports to measure and how successfully it accomplishes its goal. Test interpretation is not just about the scores; a good test provides a lens by which we can observe specific skills and forge a stronger link between data and instruction.

The fluency-test marketplace was fueled, to a large extent, by evidence that oral reading fluency is a powerful indicator of skilled reading performance (Torgesen, 1986). Note, however, that this does not mean that increasing oral reading speed boosts reading skill. Rather, fluency is more accurately conceived of as a product of automaticity and coordination of reading processes (Fletcher, Lyon, Fuchs, & Barnes, 2019).

While we all recognize that silent reading is the norm (and that silent reading is faster than oral reading), silent fluency measures, in and of themselves, are not diagnostic; they are not particularly helpful to educators. Silent reading does not permit observers to make judgements regarding accuracy; there is no way to determine whether students are, indeed, reading all the words. Two widely used measures of silent reading fluency that are part of the Woodcock-Johnson IV Tests of Achievement (Schrank, Mather, & McGrew, 2014) and the Kaufman Test of Educational Achievement, Third Edition (Kaufman & Kaufman, 2014), attempt to ensure that examinees are reading for meaning by requiring them to respond to YES/NO statements and questions. These two subtests rely, for the most part, on an Anglo-Saxon vocabulary, leaving one to ponder their validity with older students. Slasher tests, which

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require students to identify word boundaries with pencil in hand, are excellent as screeners; they provide a quick, easy, and reliable way of establishing risk status. While these tests can speak to overall rate, they cannot inform questions related to the specific nature of errors and their source.

Educators have developed strong feelings about the tests that we like and those we disdain. Many evaluators express preferences: "I like Test A better than Test B." Testing, however, is not about our feelings; it is about what the research tells us. When looking at tests of oral reading fluency, it becomes important to understand how tests are scored and what types of deviations from the text are recognized as actual errors. The Gray Oral Reading Tests, Fifth Edition (GORT-5: Wiederholt, & Bryant, 2012), for example, counts all deviations as errors; the Wechsler Individual Achievement Test, Third Edition (WIAT-III; Pearson, 2010) does not. What is a good practitioner to do? In choosing between the two (and there are other options as well), it is important to understand that all miscue-type errors (repetitions, self-corrections, and synonyms) are the result of inaccuracies in decoding. Research tells us that errors that purport not to change meaning are no less egregious than reading words incorrectly. For this reason, the GORT-5 may well be more sensitive to decoding issues than the WIAT-III. Small differences in test design can potentially have a significant impact on a child's performance.

Because dysfluent reading has its roots in word recognition, practitioners should also consider tests of word reading automaticity. Savvy evaluators know that the terms, automaticity and fluency, are used interchangeably in the test industry. Suffice it to say that fluency is possible when word recognition and oral language skills are woven into a seamless flow of thought, each strand executed with automaticity. While tests of word reading efficiency aptly identify small hesitations in word identification that are not discernable by ear, they may not pick up on those fluency challenges that reflect the impact of slow language processing. The fact is that as human beings, we are not capable of identifying small hesitations in word identification. Our sense of time is just not sensitive enough. The reason that we use tests of word reading efficiency is that those teeny tiny hesitations start to add up and become measurable when students read multiple words.

Instruments, such as the Test of Word Reading Efficiency, Second Edition (Torgesen, Wagner, & Rashotte, 2012), generally provide two lists: real words and nonsense words. Using both real words and nonsense words helps us to discern between young children who read a handful of words by sight and those who can apply their phonics skills to unfamiliar words, the latter being the hallmark of independent reading. In older students, word lists help to identify whether students have acquired basic decoding skills as a foundation for developing a rich sight vocabulary. Given, however, the small sample of skills that is possible to obtain within a window of 45 seconds, results should be interpreted with caution. The sample of decoding skills is too small to make judgements regarding mastery of specific skills. In addition, there is a lot that can go wrong in 45 seconds; gaps in attention, failure to start on cue, and noises in the distance may compromise a child's ability to demonstrate what he or she really knows.

The practitioner's job does not end with word recognition in isolation and in passages. In our efforts to improve reading skill, we have to be careful not to neglect the contribution that phonological processing, in and of itself, makes to reading fluency. The Comprehensive Test of Phonological Processing, Second Edition (Wagner, Torgesen, & Rashotte, 2013) is considered the gold standard, providing measures of phonological memory, phonological awareness, and rapid automatized naming (RAN). While we have developed an appreciation for the importance of phonological awareness, we sometimes neglect what RAN has to offer. The rapid naming of letters and numbers can be thought of as a specialized type of processing speed that lives on the cusp of visual and phonological processing; it is considered to be a measure of executive function, i.e., how we take in, store, and retrieve what we have learned. RAN speaks to the difficulty that some students will encounter in developing automaticity and their need for larger doses of instruction and practice as compared to other children with reading disabilities.

Instruction to Build Fluency

Teaching effectively to develop fluent reading that is accurate, prosodic, and fast need not be a mystery. By integrating a basic knowledge of the neurophysiology of reading development, well-considered assessment practices, and a structured approach to reading instruction, practitioners avail themselves of a roadmap for teaching reading in a way that is likely to build reading fluency over the long-term.

It is important to teach reading developmentally, in ways that are consistent with how reading networks develop in the brain. As OG educators know, phonology is the foundation of reading. Teaching children to sequence and manipulate phonemes using manipulatives helps to build the phonological route (shown in green). Basic

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phonemic awareness paves the way for easier acquisition of letter-sound correspondences, which should be learned by reading and writing letters to get those letter-sound relationships firmly in memory. Practice reading two letter words, then three letter words, by sounding each letter until it blends with the next. Practice blending while reading words complements segmenting for spelling words. Both processes reinforce detailed word memories that help children recognize words more quickly with time. Spiraling-back often provides the review and reinforcement that is necessary for automatic decoding to develop. Practice reading decodable sentences deepens the acquisition of independent word attack skills. As children read words repeatedly in context, orthographic mapping helps the word memory consolidate and become accessible through the visual word form area.

Summary

Learning to read proceeds as does the learning of any procedural skill, such as playing tennis or learning to knit. Novices begin by learning to perform basic actions, automatize those through practice, then integrate them into increasingly complex behaviors. Similarly, it is important to begin teaching reading with the goal of accuracy in word decoding, spelling, and word recognition. Encouraging novices to read faster than their natural pace will result in increased errors, due to the speed/accuracy tradeoff that is fundamental to human cognition. In addition, encouraging forced speed can have unintended consequences of increasing anxiety, encouraging guessing, and flattening intonation.

Research-based assessment practices provide a clear picture of the child's performance, indicate progress, and point the direction for future instruction. Test interpretation goes beyond scores. A good test provides a lens through which we gather data to inform instruction. Remember that all miscues (repetitions, self-corrections, and synonyms) are the result of inaccuracies in decoding. These inaccuracies result in readers accessing the wrong word, and interfere with building an accurate memory that will enable fast and accurate word recognition.

Children want to read quickly and easily, and they will do so when they are able. Dysfluent reading is usually a symptom of shaky decoding skills and weaknesses in phonological processing. Children who struggle with reading are best served by deep, sequential instruction that emphasizes accuracy and provides many hours of practice in order to build crisp memories for words that can support fast and automatic recognition. There is no magic short-cut for building fluency.

References

Ehri, L.C. (1999). Phases of development in learning to read words. In J. Oakhill & R. Beard (Eds.) *Reading development and the teaching of reading: a psychological perspective* (pp.79-108). Oxford: Blackwell Science.

Ehri, Linnea C. (2002). Phases of acquisition in learning to read words and implications for teaching. *British Journal of Educational Psychology, Monograph Series II, 1*(1), 7-28.

Farrall, M. (2012). *Reading assessment: Linking language, literacy, and cognition.* Hoboken, NJ: John Wiley and Sons.

Fletcher, J.M., Lyon, G.R., Fuchs, L.S., & Barnes, M.A. (2019). *Learning disabilities: From identification to intervention, 2nd ed.* New York: NY: The Guilford Press.

Harm, M. W., & Seidenberg, M. S. (2004). Computing the meanings of words in reading: Cooperative division of labor between visual and phonological processes. *Psychological Review, 111*(3), 662-720.

Kaufman A. S. & Kaufman, N. L. (2014). *Kaufman Test of Educational Achievement - Third Edition* (KTEA-3). Bloomington, MN: NCS Pearson

Kilpatrick, D. A. (2015). Essentials of assessing, preventing, and overcoming reading difficulties. Hoboken, NJ: John Wiley & Sons.

McCandliss, B.D. & Noble, K.G. (2003). The development of reading impairment: A cognitive neuroscience model. *Mental Retardation and Developmental Disabilities Research Reviews, 9,* 196-205.

Pammer, K., et al. (2004). Visual word recognition: the first half second. *Neuroimage*, 22, 1819-25.

Pearson, P.D. (2010). *Wechsler Individual Achievement Test - Third Edition (WIAT – III)*. San Antonio: Author.

Pugh, K. R., Mencl, W. E., Jenner, A. R., Katz, L., Frost, S. J., Lee, J. R., . . . Shaywitz, B. A. (2001). Neurobiological studies of reading and reading disability. *Journal of Communication Disorders, 34*(6), 479-492.

Schrank, F. A., Mather, N., & McGrew, K. S. (2014). *Woodcock-Johnson IV Tests of Achievement.* (WJ-IV ACH). Rolling Meadows, IL: Riverside.

Shaywitz, B. A., Shaywitz, S. E., Pugh, K. R., Mencl, W. E., Fulbright, R. K., Skudlarksi, P., Gore, J. C. (2002). Disruption of posterior brain systems for reading in children with developmental dyslexia. *Biological Psychiatry, 52*(2), 101-110.

Snow, C. E., & Burns, M. S., Griffin, P.(Eds.)(1998). *Preventing reading difficulties in young children.*

Torgesen, J., Wagner, R. & Rashotte, C. (2012). *Test of Word Reading Efficiency - Second Edition. (TOWRE – 2).* Austin, TX: Pro-Ed.

Wagner, R., Torgesen, J. & Rashotte, C .(2013). *Comprehensive Test of Phonological Processing - Second Edition.* (CTOPP2), Austin, TX: Pro-Ed.

Wandell, B. A., & Yeatman, J. D. (2013). Biological development of reading circuits. *Current Opinion in Neurobiology, 23*(2), 261-268.

Wheat, K. L., Cornelissen, P. L., Frost, S. J., & Hansen, P. C. (2010). During visual word recognition, phonology is accessed within 100 ms and may be mediated by a speech production code: Evidence from magnetoencephalography. *The Journal of Neuroscience, 30*(15), 5229-5233.

Wiederholt, J. & Bryant, B. (2012). *Gray Oral Reading Tests - Fifth Edition (GORT-5)*. Austin, TX: Pro-Ed.