How Phonemic Proficiency Contributes to Reading Proficiency

Literacy Promise Conference

March 26, 2022

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Reading Proficiency

"When reading is flowing at its best, for example in reading a mystery novel in which the vocabulary is very familiar, we can go along for many minutes imagining ourselves with the detective walking the streets of London, and apparently we have not given a bit of attention to any of the decoding processes that have been transforming marks on the page into the deeper systems of comprehension."

—LaBerge and Samuels (1974, p. 314)

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Automatic vs. Controlled Processes

- Almost all of our thinking and behavior can be divided into one of two categories:
  - **Automatic**
  - **Controlled (or Deliberative)**
- ***Automatic processes*** are effortless and require little or no conscious thought or attention
- ***Controlled processes*** require attention and require differing levels of effort depending on the task

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Automatic vs. Controlled Processes

- Examples of automatic thoughts
  - Retrieving vocabulary words from long-term memory
  - Responding to the question, "What's 2 + 2?"
  - Responding to the question "Who was the first president of the United States?"
- Examples of controlled thoughts
  - Mentally searching for synonyms or vocabulary words to do a crossword puzzle or other verbal game
  - Responding to the question, "What's 27 + 46?"
  - Responding to the question, "Who was president of the United States five presidents ago?

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Automatic vs. Controlled Processes

- Examples of automatic behaviors
  - Driving a car on a familiar route
  - Speaking normally with someone
  - Brushing your teeth
- Examples of controlled behaviors
  - Driving a car in an uncertain circumstance
  - Speaking during a word game, for example, not being allowed to use a word with a certain sound
  - Trying to get a tricky, embedded sliver out of a child's finger

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Automatic vs. Controlled Processes

- Controlled/deliberative processes, complex behaviors, and higher-level thinking are all based upon automatic processes, typically a conglomeration of automatic processes
  - For example, a basketball player taking a lay-up in a game is not putting mental effort into running or dribbling

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Automaticity is Foundational
(Part 1)

"Thus, just as a visual artist cannot become an expert without highly developed drawing skills, a child cannot become an expert in reading comprehension without automatic basic reading skills. Similarly, becoming an expert in written composition requires automaticity in the basic academic skills of handwriting and spelling (which we call *transcription*). Becoming an expert in mathematical problem solving requires automaticity in the basic number concepts and calculation skills.

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Automaticity is Foundational
(Part 2)

"Despite considerable practice, some individuals find it much harder to develop automaticity in some of these basic skills, and they may have a specific learning disorder in that basic academic skill (i.e., what is sometimes called *dyslexia, dysgraphia,* or *dyscalculia,* respectively). Other individuals may develop automaticity in a basic skill, say single-word reading, but still struggle to use that skill to understand what they read (sometimes called *poor comprehenders)*.

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Automaticity is Foundational
(Part 3)

"This view of the development of expertise in academic skills embodies a simple but powerful theoretical concept, the *resource allocation hypothesis* (Perfetti, 1998), which holds that cognitive resources are limited, so performance in a given complex academic skill depends on one's overall level of cognitive resources and on how many of those resources have to be devoted to basic skills that are not yet automatic. Hence, any complex academic skill is limited by the level of basic academic skill the person has.

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Automaticity is Foundational (Part 4)

"As a result, even a very bright child with a basic skill deficit will perform more poorly at the complex level than would otherwise be expected, because too much of the child's attention and processing resources are being devoted to a basic academic skill. Consequently, a child with a problem in single-word reading (i.e., dyslexia) will have poorer reading comprehension than his or her oral language comprehension skill would predict, because too many cognitive resources are being devoted to decoding individual words, which are not recognized automatically.

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Automaticity is Foundational (Part 5)

"Similarly, a child with poor handwriting and spelling (poor transcription skills) will have poorer written composition than his or her oral language composition skill (which we call "narration") would predict, for the same reason. And, a child with poor basic math skills (in basic number concepts and calculation skills) will have poorer mathematical problem-solving skills than his or her general ability to solve novel problems (fluid intelligence) would predict." (p. 70)

Pennington, B. F., McGrath, L. M., & Peterson, R. L. (2019). *Diagnosing learning disorders-3rd ed.* New York, NY: Guilford.

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The Role of Working Memory

- The "resource allocation hypothesis" referred to in the Pennington et al. (2019) quote is referring to the limited nature of working memory
- Working memory is the "bottleneck" between the learning environment (or anything we experience in the world around us) and our vast store of information in long-term memory (LTM)

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The Role of Working Memory

- Working memory is the temporary memory buffer we use to store information we are using at any given moment
- It is continuously being "refreshed" as our focus of attention changes
- Once we mentally move on to something else, that information is consciously replaced by our new focus
- Even though the old information leaves our attention, it remains in working memory for 10-15 seconds and then disappears

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The Role of Working Memory

- Working memory (WM) is very limited, which is why most of us can add 34 to 4,317 in our head, but not divide 4,317 by 34
  - The latter overloads our working memory capacity—there is simply too much to keep track of in our temporary, working memory "work space"

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The Role of Working Memory

Examples of working memory

- Forgetting someone's name who you just met moments ago
- Walking into another room to get something and forgetting why you went in there
- Having to look up a number or the correct spelling of a word you just looked at 20 seconds ago
- Having to re-read a long sentence because there was too much information in it

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The Role of Working Memory

- Working memory difficulties are arguably the most common phenomenon we see that cuts across difficulties in reading, writing, and math
- While WM is correlated with word-level reading, we are not sure if the relationship is causal
- However, in all likelihood it has a causal relationship with reading comprehension difficulties

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The Role of Working Memory

- Reading comprehension requires working memory to hold multiple things while reading sentences in paragraphs
- Any compromise to the amount of working memory available for reading comprehension directly compromises reading comprehension
- Thus, using controlled processes for word identification compromises reading comprehension
  - The two most common controlled processes being 1) the three-cueing approach and 2) weak, labored phonetic decoding skills
    - Phonetic decoding must become proficient, not just accurate

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The Role of Working Memory

- The best way to work around working memory limitations is to make as many processes or subprocesses for any task, activity, or behavior automatic
- Automaticity functionally bypasses working memory limitations

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Compromising Working Memory

- Unfortunately, the most common approach to reading instruction strongly (but unwittingly) encourages the perpetual use of controlled processes for determining words
  - Using multiple cues to figure out words means using multiple controlled processes, processes that are unlikely to become automatic
  - Such cues are much like a verbal game perpetually requiring controlled processes rather than normal verbal conversation that relies so heavily on automatic processes
  - Typically developing readers learn to read by circumventing the three-cueing instruction because they have sufficient phonological skills to do statistical learning and thus ***learn*** what they are not being ***taught***

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Addressing WM Limits
via efficient GPC skills

- Skilled readers automatize most of the word identification process, of which there are two levels:
  1) Efficiently determining new words via Grapheme-Phoneme Correspondences (GPCs)
  2) Efficiently remembering words for later, instant recognition
- By late first grade, typical readers can accurately and instantly (≤1 sec.) pronounce VC, CVC, and CVCe nonsense words (e.g., *ib*, *bap*, *yake*), thus displaying automaticity in letter-sounds and phonemic blending
  - That quick of a response indicates that the phonemic blending is an automatic process, not a controlled process (i.e., it is not just the letter-sound retrieval that has become automatized)

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Addressing WM Limits
via efficient GPC skills

- After applying GPCs to new, irregular, or multisyllabic words, set for variability and context can help determine or confirm the new word
- With strong GPC skills and normal vocabulary, the use of context to resolve uncertain pronunciations becomes semi-automatic
  - This limits controlled processing that may compromise comprehension
- However, the value of context in this regard is greatly diminished if the child does not produce a "close phonetic approximate" via applying GPCs throughout the whole word
  - Without a close phonetic approximate, controlled processes kick in
  - A combination of the first sound, the length of word, and context is very unreliable compared to combining a fully sounded out word with set for variability and context

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Addressing WM Limits
via a Large Orthographic Lexicon

- By second grade, typically developing readers require only 1 to 4 exposures to new words in order to remember them for later, instant recall
- Such students efficiently built a large databank of familiar, instantly accessible words for which no controlled processes are required
  - Automatic processes activate those familiar words
  - This concept seems foreign to the developers of the three-cueing model who seem to believe that improvements in the ability to apply controlled cueing processes fosters skilled reading
- Such a large databank of words appears to be the key to reading fluency

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Reading Fluency

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Reading Fluency

- One of the "Big 5" of the *National Reading Panel* (NRP)
- Fluency correlates with reading comprehension
- Fluent, effortless word-level reading frees up working memory allocation for the higher-level language processes to occur
  - Language comprehension (oral and via reading) involve both automatic and controlled language processes

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Reading Fluency

- Why do some children achieve fluency and others do not?
- This is a question often *not* asked when folks simply use reading practice (repeated reading or otherwise) to address fluency
  - Why does this child need more practice, especially if he or she seems fine at learning other things unrelated to word reading? ("I guess some kids just need more practice . . .")
  - An answer to this question can help us address fluency
  - Simple intuitive responses (practice based) have yielded very modest outcomes

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Reading Fluency

- The NRP defined fluency, but did not address the cognitive/linguistic causes of variation in fluency
  - Thus, there was limited research-supported teaching recommendations; so fluency is addressed via intuitive approaches
- Researcher Joseph Torgesen and colleagues appear to have hit on the answer in a series of articles and book chapters in the early-mid 2000, *after* the NRP's report
- There are a variety of factors (e.g., opportunity, motivation, and experience; the latter two are related)
- But Torgesen and colleagues had a more useful insight

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Reading Fluency
and the Orthographic Lexicon

- Reading fluency can be largely thought of as a direct consequence of the size of the orthographic lexicon (i.e., databank of instantly recognizable words, often called a *sight vocabulary*)

> **"It is the necessity of slowing down to phonemically decode or guess at words that is the most critical factor in limiting the reading fluency of children with severe reading difficulties . . . The most important key to fluent reading of any text is the ability to automatically recognize almost all of the words in the text." (p. 293)**

Torgesen, J. K., Rashotte, C. A., Alexander, A., Alexander, J., & MacPhee, K. (2003). Progress toward understanding the instructional conditions necessary for remediating reading difficulties in older children. In B. R. Foorman (Ed.), ***Preventing and remediating reading difficulties: Bringing science to scale*** (pp. 275-297). Baltimore, MD: York Press.

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Reading Fluency
and the Orthographic Lexicon

- What about the correlation between reading fluency and (1) reading experience and (2) rapid automatized naming (RAN)?
- Both reading experience and RAN also correlate with the size of the orthographic lexicon, so there is not likely a simple additive contribution each one is making
- Teachers cannot directly address poor RAN, and are limited in addressing reading experience, but there are ways to boost the orthographic lexicon
- Also, reading experience/practice seems to affect skilled and unskilled readers differently
  - Skilled readers—it expands the orthographic lexicon
  - Struggling readers—very limited memory for new words, this latter problem needs to be addressed

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A Question Science Needs to Answer

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How We Developed our Large Orthographic Lexicon

- Most or all of our automatic thoughts and behaviors started out via controlled processes
  - Dribbling a basketball, writing alphabetic letters, knowing the meaning of new, oral words
- Of the 30,000 to 80,000 words in your orthographic lexicon:
  - **What percentage of them, upon first encounter, did you put conscious effort into remembering for the future?**
- Thus, the process of remembering words is automatic, unconscious, and occurs "behind the scenes" while reading
  - This was not true of the math facts you learned in elementary school or the Spanish or French flash cards you used in HS and college!
- *This highly efficient memory process requires an explanation!*

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Our Multiple Memory Systems

- We have multiple types of long-term memory:
  - Episodic memory
  - Semantic memory
  - Procedural memory
  - Motor memory
  - Facial memory
  - Auditory memory and phonological memory
  - Visual memory
  - Orthographic memory
- These all vary from one individual to the next, even those with learning disabilities

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Our Multiple Memory Systems

- In neuroimaging studies, researchers see different activation patterns depending on type of memory task
- Not to be confused with "multiple intelligences," or with "learning styles" (i.e., *visual, auditory, and kinesthetic learners; or right-brain vs. left-brain learners*)
  - The Learning Styles concept been studied experimentally for decades and the consistent result has been that it offers no measurable benefits
- Knowing about different types of memory helps understand why a student can't remember written words but easily remembers faces, rules of games, details from movies, etc.
- We will focus on *orthographic memory*

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Three Types of Learning
That Affect Word-Reading Acquisition

- First, let's distinguish between ***learning*** and ***memory***
  - The latter is largely a byproduct of former
- There are three distinctly different types of learning that influence word-level reading skills (and thus proficiency)
  - **Visual-Phonological Paired-Associate Learning**
  - **Statistical Learning**
  - **Orthographic Learning**

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Three Types of Learning
That Affect Word-Reading Acquisition

- These three types of learning are typically not distinguished from one another by teachers or researchers
- Each appears to play a different role in word-level reading acquisition
- Not acknowledging these different learning processes can minimize the efficiency of our reading assessments, instruction, and intervention

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Paired-Associate Learning (PAL)

- It involves associating two things so that the presence of one activates the other
  - Language/labeling involves verbal PAL
- It is foundational for learning letter names and sounds
  - Letter learning involves visual-phonological PAL
  - The visual half of that equation is almost never the problem
- It is not the basis for written word learning
  - Yet many teaching methods seem to presume this
- PAL is normally is explicit (i.e., conscious learning)
- Dozens to hundreds of exposures to letters in K-1 are needed for accuracy-based mastery and hundreds to thousands for automaticity

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Statistical Learning

- It involves deriving patterns from multiple incidences
- Statistical learning is generally implicit learning
- Skilled readers who were never taught phonic rules or syllable types learn them anyway via statistical learning
  - (e.g., *vo* vs. *vop* vs. *vope* vs. *voap vs. vor*)
  - Other orthographic patterns learned this way
  - Source for build up of general orthographic knowledge
- Unclear how many learning "trials" are needed
  - It may vary depending on specific types of patterns
  - Currently a topic of interest in the research
- Poor readers do not display efficient statistical learning when it comes to reading

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Orthographic Mapping

- The cognitive memory *process* involved in remembering words for later, instant and effortless retrieval
  - Also applies to word parts, not just words
- Orthographic mapping is the mechanism that builds the sight vocabulary/orthographic lexicon
- The process is implicit
- New learning requires only 1 to 4 exposures
  - Thus it is *much* faster than PAL or statistical learning
- Differs significantly from from statistical learning
  - Orthographic mapping involves connections between *specific* pronunciations and *specific* letter strings (i.e., written words)
  - Statistical learning *generalizes* patterns from multiple instances

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Three Types of Learning Required for Word-Level Reading

Type of Learning	Role in Word Reading	Effort	Domain	Speed of acquisition	Skills Required
Paired-Associate Learning	Letter Names & Sounds	Conscious	Specific to specific	Dozens to hundreds or even thousands of exposures	Visual discrimination & memory phonological memory
Statistical Learning	Deriving common patterns- supports phonic decoding	Implicit	Generalize from specific examples	Unknown- likely dozens to hundreds of exposures (may vary by pattern type	Currently under study
Orthographic Mapping	Remembering specific words and word parts	Implicit	Specific to specific	1-4 exposures	Letter-Sound proficiency Phonemic proficiency

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The Amazing Orthographic Lexicon

- Skilled readers can identify a word presented for 1/20th of a second
- Skilled readers can read 150 – 250 words per minute
- Skilled adult readers have an orthographic lexicon of about 30,000 to 80,000 words
- This large lexicon is built up primarily via unconscious learning!
- Typically developing readers from Grade 2 on require only 1 to 4 exposures to new words and they are stored
- Once words are learned, they are not forgotten!

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The Amazing Orthographic Lexicon

- *Notice how different orthographic memory is compared to all other memory systems (e.g., semantic, episodic) and how different orthographic learning is from other types of learning (i.e., PAL, statistical)!*
- There are not 2, 3, 4 or more ways this can be done
  - It's amazing that we can do this at all!
- The common assumption that "children learn to read in different ways" confuses the concepts of ***teaching*** and ***learning***
- Regardless of how they were ***taught***, all skilled word readers from late 2nd grade on have ***learned*** to efficiently sound out new words and to efficiently add words to permanent memory
  - There is no alternative way to be a skilled word-level reader

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Requirements of Efficient Orthographic Learning

- Let's address the earlier question about unconscious learning of written words
- What do we need for efficient orthographic mapping?
- Let's recall the self-teaching (Share) and orthographic mapping (Ehri) models of orthographic learning
- Share:
  - New words are learned during real reading after sounding them out
- Ehri:
  - The letter strings in written words are bonded to their pronunciations stored in memory at the phoneme level
    - Phoneme-level parsing is required for this process to occur

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Requirements of Efficient Orthographic Learning

- To do what Ehri says we are doing, in the time-limited scenario under which Share says we are doing it
  AND
- To account for our experience of adding tens of thousand of words to our orthographic lexicons unconsciously and automatically, we need the following two skills:
  - ***Letter-sound proficiency***
  - ***Phonemic proficiency***
- Consider the deductive logic: If the process of adding words to the orthographic lexicon is automatic and unconscious, that means the skills needed to do that must also be automatic and unconscious

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Skills Needed for The Two Levels of Word Reading

- Phonic Decoding (correctly sounding out words)
  - **Letter–sound *knowledge***
  - **Phonemic blending**
- Orthographic Mapping (remembering words)
  - **Letter–sound proficiency**
  - **Phonemic proficiency**

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Conclusions

- Alphabetic languages are phoneme-based writing systems designed to capture the phonemic structure of spoken words
  - It should be no surprise that difficulty processing phonemes affects word reading
- Automaticity in lower level skills provides a platform for undivided WM focus on higher-level tasks, skills, or behaviors
- Word reading needs to be automatic to facilitate reading comprehension
- Reading fluency is likely to be primarily a function of the size of the orthographic lexicon
- That lexicon is built by automatic orthographic memory, which in turn appears to be powered by letter-sound skills and phoneme skills
- These must also be automatic to support an automatic memory system

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