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Reading Decoding: Cognitive Processes and Intervention Strategies

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Reading decoding skills are the basic foundation upon which all other reading-related skills are based. Children who lack these fundamental skills and do not receive any sort of intervention will grow up to be adolescents and adults with poor reading (and, by proxy, writing) skills. Of course, possessing (or lacking) strong reading and writing skills has implications that extend far beyond the classroom in the grand scheme of life, but it is in the classroom that most reading and writing deficiencies are first identified, and it is there that they must also be remedied. However, popular academic opinion varies on what exactly constitutes "good reading," or rather, reading at a rate close to or better than that of a child's peers.

In recent years, a panel of seventeen experts in the field of reading convened and developed a general definition of reading as "a process of getting meaning from print using knowledge about the written alphabet and about the sound structure of oral language for purposes of achieving understanding" (Snow, 1998, p. vi, as cited in Byrnes, 2001). As Byrnes (2001) states, what is significant about this definition is the trifold emphasis on understanding meaning of a text, knowledge of alphabetic characters and structure, and knowledge of sounds. In other words, to these experts, "good reading" is about much more than simply being able to sound out words, which is, in essence, what reading decoding skills are. Yet, without solid reading decoding skills, none of the aforementioned abilities can exist!

Another, more recent model of "good reading" comes from a more theoretical, rather than practical, approach. Seidenberg and McClelland's (1989, as cited in Byrnes, 2001) connectionist model of reading states that when one reads, one engages a number of different cognitive processes in order to process several different types of information. Additionally, the model implies that when we read, processing of information is divided among autonomous subsystems, and that once these subsystems process information on their own, they send decoded information to each other to work interactively with, rather than independent of, one another (Byrnes, 2001). This model speaks to the several different ways we approach reading (thus, the several different ways a reader can interpret meaning from a text) as well as the cognitive processes that underlie reading.

Underlying Cognitive Processes and Problems

The Orthographic Processor

The orthographic processor is the cognitive component that allows us to identify, read, and understand print-based language. It is where humans store knowledge of their language's alphabet, as well as familiar or high-frequency letter combinations, and, with sufficient activation, it allows for word recognition, all of which lead to skilled reading (Byrnes, 2001).

The orthographic processor is what allows readers to create associative relationships or "shortcuts" regarding letters and words, and store them for future recognition. In English, for example, the consonant "q" is most frequently followed by the vowel "u." When a reader of English decodes a "q" in a word, that unit of their orthographic processor will automatically cue the unit that recognizes the "qu" relationship, and does so faster than if reading a group of single letters with no pre-existing associative relationship. This process of letter association also allows us to process letters in their proper order, and to assign proper pronunciation to pseudowords. In other words, skilled readers apply pre-existing knowledge of what groups of letters *should* sound like. This allows us to say words like "froop" and "buxen" aloud, even though these words do not exist in the English language. Finally, the orthographic processor helps us to divide words appropriately into syllables. Dividing the word "party" into "par" and "ty" makes more sense to skilled readers than “pa” and “rty” because they know that the “rt” combination does not fit into any associative spoken combination in English (Byrnes, 2001).

The aforementioned functions of the orthographic processor provide readers with the most fundamental aspects of decoding: recognizing letters and letter combinations in print. When a student experiences problems with these functions, his or her ability to read is immediately impacted, particularly in the area of syntax. Kass (1966) and Lovett (1987) both demonstrate that students who have decoding problems will usually have problems with syntax, with particular regard to pseudoword tasks (as cited in Hallahan, Kauffman, Lloyd, 1999). The inherent morphological problems these students face speak not only to the syntactical function of the orthographic processor, but also to its associative properties; students with poor morphological awareness will be less likely to create significant and appropriate associative letter combinations on which they can draw, which will lead to slower, more difficult reading.

As important as orthography is to reading decoding, it alone cannot give a text meaning. Skilled readers must interpret a combination of syntax and semantics to develop a sense of context. This context will help readers in learning unfamiliar words, and also helps with reading comprehension. While seemingly tangential, reading comprehension is tied to reading decoding. Perfetti and Hogoboam (1975) demonstrated that students with comprehension deficits also performed poorly on tasks that required them to read simple words (as cited in Hallahan, et al., 1999), and other, similar studies show that students with poor comprehension are much slower than nondisabled peers in reading unfamiliar words (Golinkoff & Rosinski, 1976, as cited in Hallahan, et al., 1999), and are more likely to make errors in reading that change the meaning of a passage (Pflaum & Bryan, 1981, as cited in Hallahan, et al., 1999).

While reading comprehension is another issue for another time, the above examples were given to illustrate the significance of orthography in reading, and how the orthographic processor provides the building blocks for other reading-related tasks. As important as it is, however, the orthographic processor is only one of two processors for receiving information. The phonological processor also acts as an input device for the reading process.

The Phonological Processor

Whereas the orthographic processor forms associative letter combinations in written language, the phonological processor does the same thing for phonemes in spoken language. Familiar units in the phonological processor are activated by auditory representations of words, syllables or phonemes (Adams, 1990, as cited in Byrnes, 2001). While this may seem a redundant function to a skilled reader who can read silently to himself, the phonological processor acts as a "safety net" for even the most skilled reader. When readers happen upon unfamiliar words, regardless of their level of reading ability, the phonological processor provides another "entryway" for information to get into their brains. Because English largely adheres to the alphabetic principle (in which written symbols correspond to spoken sounds), readers of English can utilize phonological processing to recognize words that they might have heard (and know the meaning of), but never seen written down before (Byrnes, 2001). In this case, the phonological processor and the meaning processor would be working together to decode. As the reader sounds the word out, with practice, a third connection would be created between phonological, meaning, and orthographic processors, as the reader can now recognize the word in print, pronounce it, and assign it meaning.

The phonological processor also aids readers' memories for what they have just read. Since readers can only incorporate a few words at a time in their field of vision while reading, they must retain some of what they read in working memory to put the whole sentence (paragraph, chapter, etc.) together into a meaningful whole. The phonological loop and processor are closely connected, as demonstrated by the inability of some brain injury patients to retain words they just read (Byrnes, 2001).

Phonemic awareness and the phonological processor are important to fluent decoding, especially in post-1970's America, where learning to read by sounding words out is highly encouraged. There certainly exists a causal link between phonological processing and understanding word and passage meaning. Having an awareness of the relationship between phonemes and graphemes is paramount to fluid decoding skills, but without assigning meaning to a piece, one is not yet "reading," at least not by the definition cited in Snow (1998).

The Meaning Processor

Once the "input devices" of the orthographic and phonological processor have accepted text or speech, meaning must be applied to the word or sentence in order to fully decode its meaning. There are currently two distinct views of how the meaning processor applies meaning to words. The Lexical Access view proposes that word meanings are stored in an internal lexicon, and those meanings are accessed if the activation level of these word meanings is high enough (Just & Carpenter, 1987, as cited in Byrnes, 2001). The more frequently a word is accessed, the higher its level of activation. According to the Lexical Access view, a low-frequency word like "supercilious" may take longer to recall than a high-frequency word like "the" (Carpenter, Miyake, & Just, 1995, as cited in Byrnes, 2001).

The Connectionist view of the meaning processor states that each individual applies different meanings to words based on their individual experiences. Byrnes (2001) gives the example of a child who hears the word "dog," and associates that with an image of a dog with a flea collar, because every time she has seen a dog, it has had a flea collar. Even though the flea collar is not insinuated by the word "dog," that child's experience has colored the meaning of the word for her. If this is true, then "a consistent set of meaning elements would be distilled from these repeated encounters with dogs" (Byrnes, 2001). As cognition theory teaches, when a term or word can be associated with another concept, recall is aided and the word is "learned" more quickly.

The meaning and orthographic processors work closely together to assign meaning to words as the reader receives them. However, Perfetti (1991, as cited in Hallahan, et al., 1999, p. 337) noted that "readers with learning disabilities may have difficulty associating printed words with their meanings, a factor that is clearly important in understanding text." In addition to slow decoding skills, poor vocabulary and limited world experience seem to be what hinders the assigning of meaning; if a student has never flown on a plane, he may have a harder time decoding and understanding some of the related jargon than his classmate, who flies at least once a year.

The Context Processor

The context processor provides readers with structured, coherent interpretation of read text (Adams, 1990, as cited in Byrnes, 2001). This processor draws from a reader's past experiences to construct a mental image of what is being read. Connectionist model authors Seidenberg and McClelland (1989, as cited in Byrnes, 2001) assert that the context processor receives signals from all other processors, harnessing semantic, pragmatic, and syntactic knowledge to create these images. However, it seems that while all processors play a role in feeding the context processor information, its primary function is to build upon the syntactical information received, thereby making the context-meaning relationship stronger than the relationship with the phonological or orthographic processor.

When disabilities exist that manifest themselves in the context processor, students have difficulty understanding and constructing syntactically correct sentences. They may omit important punctuation or have difficulty constructing multiple syntactic structures for tricky sentences (e.g., the vagueness of the modifier in the sentence, "The burglar saw the cop with binoculars" [Byrnes, 2001]). One syndrome that can affect the context processor is Broca's Aphasia. Individuals with this syndrome are unable to differentiate between sentences that contain the same words, but in a very different (and thus context-altering) syntax. Byrne (2001, p. 131) offers two sentences: "They fed her the dog biscuits" and "They fed her dog the biscuits." While these sentences evoke entirely different (though entertaining) mental images (the function of the context processor), Broca's Aphasia patients would be incapable of discerning between the two because their syndrome limits their mental processing of syntactical differences. The fact that Broca's Aphasia (an injury to the Broca's area of the cerebral cortex) does adversely affect the context processor has led some researchers to believe that the human brain does contain an inborn predisposition to grammatical structure and syntax (Byrnes, 2001).

Problem Remediation

Many of the empirically supported strategies for intervening in reading decoding difficulties focus on the orthographic and phonological processors. As these engage the most basic elements of reading decoding, most researchers tend to be in agreement that these areas are key for remediating decoding problems. Furthermore, early identification of such learning disabilities is important in minimizing the effect of the disability. In a perfect world, psychologists would be able to predict which children will develop reading disabilities and begin intervention as early as possible. Unfortunately, "predicting exactly which children will develop a reading disability (RD) has proved problematic. Errors of both underprediction and overprediction have made accurate early identification of students with reading disabilities difficult" (Jenkins & O'Connor, 2001, p. 3). While researchers seek to fine-tune their assessment methods, intervention methods must not only seek to remediate current issues, but "undo" possibly several years of the student's "homegrown" coping mechanisms.

Orthographic Remediation

The "development of strong orthographic representations" is key to both children and adults with reading disabilities in order to allow them to read "quickly and effortlessly" (Hook & Jones, 2002). "Fischer (1994) has developed drills to 'train the orthographic processor' which involve having the student mark the vowels long or short based solely on the letter patterns contained in the word. They do not actually read these words, but instead focus attention on the letter patterns" (Hook & Jones, 2002, Word Level – Automaticity section, para. 7). Students who engage in this drill will next say only the vowel sound of the word (rather than the whole word); theoretically, this should engage both the orthographic and phonological processors and create a working linkage between the two.

Another method of engaging the orthographic processor involves flash cards. Students may be given cards with different syllable types on them. They must then sort the cards into piles by syllable type, saying the vowel sounds of each one out loud as they sort. These drills can also be adapted and used for single words, irregular words, and polysyllabic words, for "engaging higher-level concepts of structural analysis" (Hook & Jones, 2002, Word Level – Automaticity section, para. 9). Hook & Jones (2002) also suggest a multisensory approach to orthographic training that "link the motor and visual modalities to reinforce the auditory" (Hook & Jones, 2002, Word Level – Automaticity section, para. 10). While techniques such as tracing and copying are neither new nor unique (Hook & Jones recommend Gillingham and Stillman, 1997 and Raines, 1980 for elaboration), "sky writing" requires the student to use his whole arm to create letters and words in the air, the aim of which is to "improve symbol imagery, or the formation of orthographic representation (i.e., Seeing Stars Nanci Bell, 1997)" (Hook & Jones, 2002, Word Level – Automaticity section, para. 10). The authors (2002) elaborate:

> This technique involves having the student look at a word or word part pronounced by the teacher, name the letters, and then use his finger to write the word in the air directly in his visual field while looking at his finger. The student then reads the word from memory and the teacher questions him about the order and placement of specific letters in the word (e.g., What is the third letter in the Syllable?" "What is the second letter?" etc.). The emphasis here is on enhancing the students' ability to "see" the letter patterns in their minds. (Word Level – Automaticity section, para. 10)

Orthographic remediation for readers with dyslexia has also been researched, with positive results. Seymour and Bunce (1994) treated RC, a developmental surface dyslexic/dysgraphic, by approaching both "lexical and sublexical development in orthography development" (Brunsdon, Hannan, Coltheart, & Nickels, 2002, p. 391). Seymour and Bunce trained RC in reading words that consisted of initial consonant, vowel, and terminal consonant clusters, and eventually expanded to more complex consonant clusters. One interesting strategy employed by Seymour and Bunce was to have RC solve anagram puzzles of target words, broken up by clusters (e.g., EE SH P = SHEEP). Similarly, RC used a color-coding system to construct words (both by multicolored flash cards and multicolored pens). In this system, all initial consonants were blue, all vowels were red, and all terminal consonants were green. Ultimately, this treatment was deemed successful due to a marked increase in RC's reading of both words and non-words (Seymour & Bunce, 1994, as cited in Brunsdon, et al., 2002).

Phonological Remediation

Instructional emphasis on phonological awareness as a means of reading intervention has been promoted over the better part of the last two decades (Adams, 1990; Brady & Shankweiler, 1991; Vellutino, 1991; as cited in Foorman, Francis, Winikates, Mehta, Schatschneider, and Fletcher, 1997). Jenkins and O'Connor affirm that "targeted phonemic awareness instruction with prereading children…leads to significant gains in phonological awareness and in word-level reading skills," but also caution that "merely incorporating phonemic awareness training in kindergarten is insufficient to overcome the challenges faced by students at risk for reading/learning disabilities" (2001, p. 5). They suggest that a more-explicit approach to phonics instruction is more beneficial to beginning readers (both normal and at-risk readers) (National Reading Panel Report, 2000, as cited in Jenkins & O'Connor, 2001), but also maintain that empirical studies of the more-explicit approach display a smaller effect for remedial readers than beginning readers.

Foorman, et al. (1997), reached somewhat similar conclusions in their comparative study of the effectiveness of three different approaches to reading interventions. Upon comparing the results of instruction in synthetic phonics (focus on phoneme), analytic phonics (focus on onset-rime), and sight word (focus on whole word) methods, they found the synthetic phonics approach to be superior to either of the other two approaches. While Jenkins and O'Connor do not discuss phonics instruction as a part of a larger instructional program, Foorman, et al. preface their study with an outline of several examples of successful phonics instruction:

> Vellutino et al. (1996) found that 15 weeks of 30 min daily of one-on-one tutoring that emphasized phonemic awareness, the alphabetic principle, sight-word vocabulary, and comprehension strategies was successful in remediating first-graders. Torgesen, Wagner, Rashotte, Alexander, and Conway (1997) reported impressive gains with reading-disabled students (10 years old, on average) who received one-on-one tutoring using synthetic and analytic phonics with a skilled clinician for 2 hr daily over 8 weeks (with 8 hr follow-up in the learning-disabilities classroom). Brown and Felton (1990) found significant trends in their reading data supporting structured phonics instruction…over literature-based instruction…for first graders at risk for failure due to poor phonological processing skills. (Foorman, et al., 1997, p. 256)

In Foorman, et al.'s study, the most significant gains in word reading and phonological processing were made by the group instructed in synthetic phonics. The largest discrepancy between the aforementioned success stories and Foorman's is that unlike Vellutino and company, Foorman's test group (and most students) was instructed in large-group, whole class settings. Despite this, Foorman, et al. set forth a strong argument for integrated phonics instruction. The most successful program, which was modeled on the Orton-Gillingham approach, consisted of the following activities:

> (a) teach[ing] phonics directly by introducing letter names and sounds first and blending skills soon after; (b) us[ing] a multisensory approach by teaching letter-sound associations through auditory, visual, and kinesthetic modalities; and (c) follow[ing] a systematic, step-by-step approach proceeding from simple to complex in an orderly progression (Foorman, et al., 1997, p. 260)

Correlations can be drawn between the successful remediations outlined here and those outlined under the Orthographic Remediation section. In both areas, multisensory approaches in conjunction with discrete phonics instruction are empirically supported as the most effective teaching strategies.

Meaning and Context Remediation

The use of word lists and discrete vocabulary instruction can potentially be helpful in aiding decoding. Empirical opinion seems to be divided on the value of decontextualized v. contextualized learning, particularly with regard to vocabulary. Goodman (1965) found that children read words in context much better than in lists (as cited in Hallahan, et al., 1999). However, it is theoretically plausible to assume that repeated exposure to specific vocabulary words, first decontextualized, then in context, would reinforce learning and thus aid decoding. Nicholson (1991, as cited in Hallahan, et al., 1999) noted that in Goodman's original study, children read well in context because they had already seen target words in a list. After seeing the words on the list, it was understandably easier for them to read the passage, resulting in fewer reader mistakes.

On the other hand, there is also contemporary support for Goodman's original claim. Learning words out of context can be "fast and efficient, especially when used with mnemonic techniques. Average learners can 'learn' 30-40 words per hour… Decontextualized learning is useful for fast initial learning, while learning from context expands, extends, deepens and broadens the initial stage" (Waring, 2000). The key words here are likely "average learners;" it is difficult to say which is more appropriate for the reading disabled student. Either theory is plausible, and both theories are also empirically supported. The time-honored tradition of "trial and error" may be necessary to determine which method is appropriate for a given student or group of students.

In the case of an individual with Broca's Aphasia, most of the hundreds of treatment options fall into one of two categories: loose training and classical structured approach (Conley & Coelho, 2003). In Conley and Coelho's treatment of a 57-year-old woman with severe nonfluent aphasia, they established baseline performance by presenting thirty stimuli on flash cards at random, asking the patient ("LP") to recall the noun represented on the card each time. No cueing or feedback was provided in baseline probes. During treatment, Conley and Coelho incorporated elements of both loose training (*Response Elaboration Training* – RET) and classical structure (*Semantical Feature Analysis* – SFA).

When SFA was implemented during treatment, LP was "prompted to produce the semantic features…that included: category, function, properties, location, and any association with the object. This technique was used to activate a semantic network surrounding the stimulus in order to facilitate recall of the word" (Conley & Coelho, 2003, p. 206). In the RET phase of treatment, "semantic features were presented and prompted to facilitate target responses…all responses were expanded and modelled [sic] for the individual" (Conley & Coelho, 2003, p. 206). By expanding upon these responses, the researchers hoped to further stimulate semantic fields surrounding target words. In short, researchers attempted to engage LP in associative verbalization in order to reach the target word.

The combined SFA and RET approach was successful in helping LP, not only to improve her word recall dramatically during treatment, but also in follow-up sessions six weeks after treatment, when her scores were still significantly higher than her baseline scores. While it may be rare for a teacher to have a student with Broca's Aphasia in his class, it is worth noting the success of a combined SFA and RET approach a) because of its relevance to remediating severe problems in the context processor, and b) it mirrors the popular theory that the best approach to teaching reading is a combined whole-language/phonics-based approach, and certainly also mirrors Foorman, et al.'s findings about the efficacy of the synthetic phonics program for remediating phonological difficulties.

The intervention and remediation techniques described in the current paper are by no means an exhaustive compilation; they merely represent a cross-section of the currently available research. As always, the best course of action for a teacher who is unsure of which approach to use is to sample several, combine a few, and gauge the results from there. Empirical research is helpful in pointing the classroom teacher in the right direction, but ultimately, personal experience is the best teacher.

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Addendum: Reading Decoding IEP Interventions

1. Provide student with a list of target vocabulary words and definitions and review prior to reading a text.

Nicholson (1991) built upon Goodman's (1965) original study, which claimed that students learn words better in context than from a list (as cited in Hallahan, et al., 1999). Nicholson's assertion was that children read well in context because they had already seen target words in a list. After seeing the words on the list, it was understandably easier for them to read the passage, resulting in fewer reader mistakes. Though a valid argument exists in favor of decontextualized learning, for the student with reading disabilities, the discrete vocabulary instruction prior to reading the word in context provides rehearsal and reinforcement, and is probably the better way to go.

2. Conduct "air writing" drills with student to strengthen development of symbol imagery.

This multisensory intervention is aimed at the beginning reader who is experiencing difficulty with letters. Students must look at a letter or word provided by the instructor, listen to the teacher pronounce it, then use their fingers to draw the letters directly in their own field of vision while watching their fingers. The teacher then quizzes the student on letter order and specific placement of letter (e.g., "What is the fourth letter?" "What is the second letter in the first syllable?"). The theory behind this is to engage tactile-kinesthetic, auditory, and visual cues to increase familiarity with letter patterns. This technique speaks to the orthographic processor, and its success as an intervention with deficient beginning readers has been documented (Gillingham and Stillman, 1997; Raines, 1980; Bell, 1997; as cited in Hook & Jones, 2002). Foorman, et al. (1997), made similar discoveries in comparing the efficacy of various phonics instructional programs.

3. Conduct flash-card "sorting" drills with student to increase familiarity with sound-symbol correspondence.

Students will be given cards with different syllable types on them. They must then sort the cards into piles by syllable type, saying the vowel sounds of each one out loud as they sort. These drills can also be adapted and used for single words, irregular words, and polysyllabic words, for "engaging higher-level concepts of structural analysis" (Hook & Jones, 2002, Word Level – Automaticity section, para. 9). While empirical support is at a premium (Hook & Jones seem to think it's a good idea, but never offer any solid evidence as to *why*), theoretically, it seems sound. Students who engage in this activity will rehearse sounds and develop associative relationships between similar sounding vowel sounds (e.g., *ea* and *ee*).

4. Provide a combined approach to phonological instruction that emphasizes phonemes over onset-rime or whole word instruction.

Foorman, et al. (1997) conducted an experiment in an urban elementary school in which they instructed fourteen special education teachers to teach their second- and third-grade students either synthetic phonics (phoneme emphasis), analytic phonics (onset-rime emphasis), or sight-word (whole word emphasis) programs for one year. Though the original hypothesis stated that the analytic phonics approach would produce superior results, the researchers were surprised to learn that the students who learned via synthetic phonics not only outperformed the analytic phonics group in terms of growth-curve analysis of phonological and orthographic processing, but they also outperformed the sight-word group in orthographic processing (Foorman, et al., 1997).

The activities involved in the synthetic phonics approach are based on the Orton-Gillingham approach, which include:

> (a) teach[ing] phonics directly by introducing letter names and sounds first and blending skills soon after; (b) us[ing] a multisensory approach by teaching letter-sound associations through auditory, visual, and kinesthetic modalities; and (c) follow[ing] a systematic, step-by-step approach proceeding from simple to complex in an orderly progression (Foorman, et al., 1997, p. 260)

Specific activities include focusing on each letter of the alphabet, employing reading and spelling decks, reading practice, handwriting practice, spelling practice, listening activities, and frequent review. There is less (if any) emphasis placed on discussion of word meanings or rote memorization, the key differentiating factors of the other two approaches.

5. Employ the Corrective Reading Program with the student.

The Corrective Reading Program is a Direct Instruction method of teaching that has been proven effective in improving the reading of students with learning disabilities (Lloyd, Epstein, & Cullinan, 1981; Maggs & Maggs, 1979; Polloway, Epstein, Polloway, Patton, & Ball, 1986; White, 1988; as cited in Hallahan, et al., 1999). This approach is intended for students who already have a grasp of individual letter names and sounds, but require guidance in combining those sounds to increase oral reading accuracy.

CRP includes daily lesson "scripts" ordered specifically to help students build upon what they learn in previous lessons. They read from word lists and engage in group and individual readings of stories. An example of this task-analytic approach to reading decoding comes from a unit mastery test Englemann, Becker, Hanner, and Johnson (1988, p. 119-120, as cited in Hallahan, et al., 1999, p. 347):

met

1. Point to **e** in **met**. **This letter does not say eee in the words you're going to read now.**

2. Point to **e** in **met**. **This letter says eee. What sound?** Touch. *eee*.
3. (Test item.) Tough the ball of the arrow. **What word?** Slash right. *Met.*
4. Repeat steps 2 and 3 for **them, shed.**

Such mastery tests occur after about every five days of instruction; they are brief and explicitly connected to what students have been learning to allow for close monitoring of progress (Hallahan, et al., 1999).