The insights of Carol Chomsky into how a young child acquires language across time changed the field of reading research in profound ways, some of which are only now coming to full fruition. Synthesizing work from linguistics, education, and child development, Chomsky challenged linguists to study language development beyond the age of five and challenged educators to incorporate research on language development for the children who could not learn to read easily. She also helped make “invented spelling” a highly influential description of children’s first writing attempts that could be useful in learning to read. (Chomsky, 1971) In the first part of the chapter, we review briefly some of the better-known aspects of her scholarly work. In the bulk of the chapter, however, we discuss the most recent and least known outgrowth of Carol Chomsky’s legacy --- what she colorfully described in her article, “After decoding-what?” (Chomsky, 1978).

More specifically, in this later section we describe a view of fluent reading comprehension in which linguistic knowledge is critical for both the diagnosis and intervention of reading disabilities. We provide a theoretical overview of how explicit instruction in multiple areas of linguistic development can propel children’s acquisition of written language from decoding to fluent comprehension. We then describe an application of these principles in an innovative curriculum designed by us to assist struggling readers in the development of their knowledge in areas ranging from phonology to syntax. Finally, we present efficacy data that show the significant impact of these areas of knowledge on the acquisition of written language, a fundamental assumption made by Chomsky three decades ago.

Background

Carol Chomsky is probably best known for her study into the development of syntax in children beyond the age of five (Chomsky, 1969). In this groundbreaking study thirty-six children between the ages of six and ten were evaluated for their ability to comprehend specific complex structures of English syntax. Nine structures were investigated and the results revealed that the acquisition of five of the structures proceeded in a predictable sequence.

The syntactic structures under investigation included: 1) Easy to see (The doll is easy to see.); 2) Promise (Bozo promises Donald to stand on the book.); 3) Ask (The girl asked the boy what to paint.); 4) And (Mother scolded Gloria for answering the phone, and I would have done the same.); and 5) Although (Mother scolded Gloria for answering the phone, although I would have done the same). These five structures represented a developmental sequence of acquisition. None of the children who did not comprehend structure 1 could comprehend any of the other constructions. All of the children who comprehended structure 5 also comprehended the other four constructions.
These data bear a great deal of similarity to earlier data from researchers like Roger Brown (Brown, 1973) and Ursula Bellugi (Brown & Bellugi, 1964; Klima & Bellugi, 1966), who discovered similar acquisition sequences in younger children. The implications of Chomsky’s findings demonstrated that syntactic aspects of language acquisition are not complete upon school entry. Further, she demonstrated that this acquisition process proceeds beyond the age of five in a manner identical to other aspects language acquisition in the young child—systematically and without direct instruction. Through this research Chomsky cautioned that these findings may be just the “tip of the iceberg” and that the linguistic structures yet to be acquired could be fairly extensive.

Chomsky’s primary area of investigation in language development extended to the acquisition of written language. In the above-described investigation of linguistic development, she also analyzed the relationship between language development and exposure to reading material. Information regarding IQ, SES, and the amount and complexity of reading material to which the child was exposed was gathered. Questionnaires were given to the parents and the children and the children were asked to keep daily records of their reading. The reading survey included Charlotte Huck’s Taking Inventory of Children’s Literacy Background, a multiple-choice quiz measuring knowledge of common books and stories. Before any other researcher Chomsky found important insights into the relationships between the child’s linguistic stage and three variables: the Huck score (i.e., the child’s knowledge of books); the average complexity of books named by the parent; and the child’s IQ. In other words, linguistic development was closely related to the quantity and complexity of reading material to which the child had been exposed by the parent. In one of the most influential of her papers she advocated that one of the best predictors of the young child’s future reading was the time the parent read to the child (Chomsky, 1972). As the children grew older, their linguistic development became more closely related to their own reading behavior than to the reading performed by the parent. These early conclusions by Chomsky were borne out repeatedly over the last three decades (Snow, 2002; Wolf, 2007).

Chomsky also actively advocated that writing instruction precede reading instruction. In a paper presented at a conference on the Theory and Practice of Beginning Reading Instruction (Chomsky, 1976), she asked the participants to consider a set of anecdotes regarding children who begin to write before they learn to read. Although these children did not receive explicit spelling or writing instruction, the characteristics of their “invented spellings” bear some striking similarities: 1) long vowels are represented by letter names (BOT boat, FEL feel); 2) short vowels are represented by the letter name which contains the closest sound (BAD bed, WOTR water); 3) L and R are spelled without vowel support (GRL girl, KLR color); 4) nasals are omitted before consonants (WOT won’t, PLAT plant); and, 5) some words are spelled using the full name of the letter (YL while, THAQ thank you).

Chomsky found that different children converge on very much the same system of spelling and that this system is both systematic and uniform. Based on these and other findings, Chomsky suggested that some aspects of reading acquisition may be approached through the teaching of writing. In combination with large amounts of exposure to reading and listening materials, this method provides the children with the raw materials of letters, sounds, and words to interact with text. This experience with spelling, in turn, helps children actively hypothesize how words are
represented in written language. Charles Read and many other researchers replicated and extended Chomsky’s early insights into “invented spelling” (Read, 1986).

One of the most pertinent directions in Carol Chomsky’s work that has directly and indirectly influenced our own research into the development of written language in children with dyslexia, concerns her insights into children who struggle to acquire reading. Then and now the largest research questions and emphases among researchers targeted the acquisition of early decoding at the word level. As alluded to earlier, Chomsky asked a different level of question: what happens after decoding, when children must become fluent readers and comprehenders of more sophisticated sentential level text? Towards that end, Chomsky (1979) performed different experiments with instructional methods to improve reading fluency in a small group of teacher-referred struggling readers. In her method children listened to a recording of text by a competent adult reader, while they read along silently. Chomsky proposed that by essentially memorizing a text, the children would begin a tacit, deeper discovery of text and would be motivated to read more on their own. Chomsky’s end goal was that the child should be “…bathed in inputs with which he interacts” (Chomsky, 1979). Very importantly to our present research, she suggested that if any of the children were not making progress listening and reading along with the recording, a range of activities were to be added which emphasized the development of automatic knowledge in English orthography, in morphology, in text writing and in comprehension strategies. In so doing, Chomsky’s methods foreshadowed both what would become one of the most-used methods for teaching fluency---called repeated reading methods---and also the multi-componential approaches to the remediation of fluency that will be described shortly.

Until recently, Chomsky’s influences were, in essence, only half incorporated in reading research and in classroom practice through the almost universal use of repeated reading methods. The second half of her thinking---about children who fail to make gains with repeated reading methods---was less pursued for many years. Described below, her concomitant suggestion of directly and explicitly emphasizing other major linguistic systems for the children who do not progress with repeated reading is now part of the foundation for our multi-component intervention for fluent comprehension in dyslexia research.

In sum, the work of Carol Chomsky strongly emphasizes the link between linguistic knowledge and the acquisition of written language for those who acquire reading easily and for those who struggle. In her view, the child comes to school with a great deal of knowledge about language that can be actively engaged in the process of learning to read. Each new piece of evidence about language---from the interaction of sounds and letters, the use of words in different contexts and their different meanings, to the varied structure of sentences---invites children to examine their theories about their native language and make adjustments that incorporate this new knowledge. To Chomsky, the more evidence a child is exposed to, the more likely the child is to become an advanced user of the language, oral and written. When this immersion, however, fails to adhere, for whatever reason, then these other various sources of linguistic input need to be addressed for the child.
Theoretical and Applied Implications of Chomsky’s Work

Our own work has been fundamentally influenced by Chomsky’s preliminary insights into the struggling reader. Through a synthesis of cognitive neurosciences, child linguistics, education, and child development, we have examined the processes that young brains require to identify words when reading. Our results and the results of other researchers point to the use of exquisitely precise attentional, linguistic, visual, and cognitive systems. Together these systems enable the reading brain to recognize letters and familiar letter patterns; to connect this information to the stored, corresponding phonemes; and almost simultaneously, connect this cumulative information to the meaning(s) of the word, its grammatical uses, its potential incorporation of morphemes, and its usage in social contexts (pragmatic knowledge). Most importantly, the brain must retrieve, connect, and integrate all this information in a fraction of a second in order to have time to comprehend the word in text.

Although, as noted, a great deal of research over the last decades has been successfully devoted to understanding the decoding phases during the reading act, we have been far less successful as a field in understanding and remediating the end of reading acquisition---that is, fluent comprehension. Just as Carol Chomsky recognized in her early work with struggling readers, many of these children can learn to decode, but not rapidly enough to allocate time to critical comprehension processes. Using cognitive models of word retrieval and reading, we set out to understand each of the component processes involved in decoding and fluent comprehension.

The background for these models included evidence from research in aphasiology and in acquired and developmental dyslexia with regard to how the brain learns to read in typical development and fails to read in adults with discrete areas of brain injury and in children with reading disabilities (Pugh, Sandak, Frost, Moore, & Mencel, 2005; Wolf, 2007). An examination of the young reader’s first “reading circuit” illustrates the many components initially involved---from visual pattern recognition systems to varied cognitive and linguistic systems (Tan, Spinks, Eden Perfetti, & Siok, 2005; Sandak, Mencel, Frost, & Pugh, 2004). As the child progresses, however, more and more linguistic knowledge becomes essential to understand the many dimensions contained within a written word: i.e., phonology, orthography, morphology, syntax, semantics, pragmatics. Each system activates specific areas of the brain when we read. A conclusion from this research and what will become the cornerstone of our intervention is that everything the child knows about oral language contributes in some way to the development of written language and to the automatic access of all the processes needed to ensure rapid comprehension of what is read.

Although correctly emphasized in most instructional decoding programs, phonological knowledge is, nevertheless, necessary but insufficient for reading fluency. As Carol Chomsky found, automatic access to the common orthographic patterns in English is important, as well as morphological knowledge and strategies for comprehension and rich writing efforts. In essence, she was the first researcher, to our knowledge, to begin to target the development of additional linguistic systems, like semantics and morphology. Ironically, perhaps, she did not include in her particular study her own findings on the importance of increased syntactic knowledge for children between 5 and 9 for the fluent comprehension of more sophisticated text level reading.
It is now clear to us that the development of knowledge in each of these linguistic areas becomes even more essential for comprehension at the sentential level, with morpho-syntactic knowledge of increasing importance over time. For example, rich semantic knowledge both plays a significant role in children’s reading comprehension and impacts fluent word recognition. Semantic knowledge refers both to the size of a vocabulary, and also to the strength and depth of individual word knowledge (Frishkoff, Collins-Thompson, Perfetti, & Callan, 2008). Consider the multiple meanings of the word “duck”. When functioning as a noun, it represents a relatively charming, web-footed, swimming bird; as a verb, it means to avoid; and if you live in Boston, it is an adjective for the charming “duck tours” on vehicles that traverse both harbor and land! It is important to stress that a great many of the most common children’s words are equally polysemous. The more knowledgeable children are about a word, its multiple meanings, and various pragmatic and syntactic contexts, the more rapidly the word is processed during its reading in sentential contexts (Locker, Simpson & Yates, 2003). As a result, children can move into more sophisticated text-level reading with greater fluency. This, in turn, allows more time to be allocated for understanding. In short, the semantic system not only affects the speed of accessing the word, but also significantly impacts a deeper comprehension of text.

The implications of this conclusion are significant. Investigations into “word poverty” (Moats, 2000) and the effects of impoverished word environments demonstrate the significant and long-term impact of a child’s vocabulary size on his/her reading comprehension (Stanovich, 1985). Moats (2001), for example, estimates that there is a 15,000 word gap between lower-income and higher income children who enter first grade. The significance of this finding is brought home by Biemiller (2005), who found that kindergarten children with a vocabulary in the bottom 25% remain behind in vocabulary and comprehension into middle school and often well beyond.

Related to both semantic and orthographic knowledge is the least emphasized linguistic component of reading---- morphological awareness. Morphological knowledge in young children refers to the conventions that govern word formation, and the ways in which roots and affixes create new word meanings. For example, children need to learn that adding the suffix morpheme “s” to the root “duck”, can create the plural noun “ducks” or the present, singular verb; while adding “ing” creates the present participle “ducking”; and adding “ed” creates the past verb form “ducked”. Such morphological knowledge provides the child with critical disambiguating syntactic information in sentences (e.g., “ed” rapidly clarifies that “ducked” is the verb form). Because the role a word has in sentence structure helps determine its meaning, this collective morpho-syntactic information propels comprehension.

While morphological awareness is critical in most languages, it plays a particularly important role in English, which is, of course, a morphophonemic language that represents both morphemes and phonemes in its spelling. Words that are irregularly spelled no longer seem as arbitrary in their spelling when children understand their morphemic roots. To take a well-used example (from N. Chomsky & M. Halle, 1968), the word “muscle” connects this seemingly irregularly spelled word to its basic roots. In so doing, it illumines the semantic relationships among words like “muscle”, “muscular”, and “musculature”. From this perspective, by conveying semantic, syntactic, and orthographic information, morphological knowledge contributes to the development of spelling, to faster word recognition, and to fluent comprehension.
We have reserved for last, the singular importance of a growing syntactic base for comprehending text. Like morphology it represents another less emphasized component in reading intervention, despite the fact that syntactic knowledge is of exponentially increasing importance over the school years. Knowledge of how words are used within different grammatical or syntactic contexts is essential for the child’s growing fluency and comprehension. Just as Chomsky demonstrated in her study of syntactic constructions, children’s syntactic knowledge is acquired over time. Analogous to the extensive research into the reciprocal relationships between vocabulary knowledge and reading, a similar reciprocity exists between syntax and written language. Children who read a variety of increasingly sophisticated sentence constructions have enhanced comprehension and more syntactic knowledge. Children with highly developed syntactic knowledge, in turn, comprehend text with more complex syntactic constructions better and more rapidly than those with less syntactic knowledge.

If we would try to summarize the existing research on what the young human brain learns to connect when it reads a single word, it would be an impressive panoply of multiple linguistic components, perceptual systems, and cognitive processes. Further, that developing brain must learn to retrieve, connect, and integrate all the information from these processes in a fraction of a second. The precision and rapidity involved in integrating all these components (i.e., fluency) enables the young reader to have the time necessary both to comprehend the meaning of the author and to connect this meaning to his or her own thoughts and insights. Without fluency, without fluent comprehension, the reader is virtually bereft of the ultimate goal of reading: an understanding that goes beyond the text into insight and discovery.

RAVE-O Intervention: An Applied, Unfolding Legacy from Carol Chomsky

The RAVE-O intervention is an unusual reading program that shouldn’t be unusual at all. Indeed with no small historical humility, the program bears notable resemblances to the first known reading pedagogy by the Sumerians, who had no previous models or methods to guide them (Wolf, 2007)! The intervention’s purposes are to teach young reading brains how to build up and rapidly retrieve all the sources of visual, cognitive, and linguistic information described above and connect them during reading. The ultimate goal is to teach the struggling reader to read rapidly enough to be able to understand the text and think for themselves about what they read.

Based on theoretical accounts of reading fluency and comprehension (Wolf & Katzir-Cohen, 2001), the program attempts to simulate what the brain does when it tries to read a single word with fluency and comprehension. RAVE-O’s basic premise is that the more the child knows about a word (i.e., phonemes, orthographic patterns, semantic meanings, syntactic and pragmatic uses, and morphological roots and affixes), the faster the word is decoded, retrieved, and comprehended. RAVE-O is not so much a wholly new program, as it is the application of insights from Chomsky and cognitive neuroscience when connected to “best teaching practices” and some newly-designed activities that can systematically address multiple linguistic, cognitive and affective systems.

To make the program come to life, a few examples will suffice. Each week children learn all the relevant phonological, orthographic, semantic, and syntactic content for a small group of core words and learn to make explicit connections across these linguistic systems.
Making these connections is key to re-enacting what the brain’s “reading circuit” does. For example, with the word “jam”, the instructor first reviews the individual phonemes, /j/ + /a/ + /m/, and then teaches the child to find the chunks in “jam”: that is, the rime (/am/) and the onset or starter (/j/). This step consolidates phoneme-level knowledge and connects it to orthographic patterns. Almost immediately this knowledge is then connected to the semantic base. The word “jam” possesses at least three common meanings and can be used in different syntactic functions (as noun and verb) and pragmatic contexts (e.g., a musical “jam”). Moreover, “jam” can be easily changed by the addition of different morphemes (e.g., jams, jamming, unjammed) to show how words can change, but still have their root visible. The uniqueness of RAVE-O is that explicit attention is given to learning and connecting the major linguistic components in every word, and in every teaching unit of the program.

A continuum of game-like activities offers whimsical means to teach children to connect individual phonemes, to orthographic units, to meanings, to uses. In turn, these connections facilitate rapid decoding and comprehension processes and improve spelling along the way. Speed Wizards involves a set of computerized games designed to reinforce these same sets of processes at different levels of complexity and three speeds of recognition. Word Webs are a regularly recurring semantic exercise where the child’s knowledge of the different possible meanings are elicited and then represented by image cards on a huge web. The web provides a simple, visual way of illustrating how words are interconnected; simultaneously, the image cards provide important visual imagery that aid both storage and retrieval from memory for children who are often characterized by word-retrieval difficulties.

A range of metacognitive strategies (called Magic Tricks) enables children to segment the most common orthographic and morphological units in words. The tricks are quick, often humorous mnemonics that teach key strategies about words. For example, the strategy called Ender Benders helps children quickly recognize common morpheme endings that change (that is, “bend”) the word’s meaning. The Think Thrice Comprehension Trick is a set of three comprehension strategies to enhance the child’s prediction skills, comprehension-monitoring skills, and the child’s analytical and inferential skills. The third of these strategies sounds deceptively simple: “Think For Yourself”. In reality, it represents a concrete embodiment of the “Proustian principle”, that is the ultimate goal of RAVE-O and reading itself---going beyond the author to think new thoughts.

These meta-cognitive comprehension strategies become almost daily implemented through a series of specially written RAVE-O Minute Stories. Each story is introduced and then followed by the teacher guiding the child in the use of the strategies. In addition, the stories’ controlled vocabulary incorporates the phonemic and orthographic patterns, multiple meanings, and varied syntactic contexts of core words. The Minute Stories represent, therefore, multi-purpose vehicles for facilitating more automatic rates within phonological, orthographic, syntactic, and semantic systems at the same time that they reinforce the use of the most important strategies for understanding stories and thinking their own thoughts. In the process, the stories build an ever-important affective dimension for the children, who often feel disenfranchised from learning and from their own language. The content of the Minute Stories provides a platform for exploring the dejected feelings struggling readers often have about learning to read.
The various “Magic Tricks” and whimsical activities for word play may appear light-hearted and fun-filled, but our goals for them are very serious. Children who are struggling readers need to learn the interconnected nature of words, and they usually don’t. The collective activities, the use of specifically designed computer games, and the novel-sounding strategies provide a deeply important, systematic foundation for some of the most important skills used in all later learning.

Summary of Results

The effects of RAVE-O with struggling readers have now been studied for ten years in federally funded research in three contexts: 1) a pull-out intervention in the school during the school day; 2) an intensive summer-school remediation program; and 3) an after-school intervention. In each of these studies, RAVE-O is combined with a systematic phonological analysis and blending program (e.g., SRA Reading Mastery or Orton-Gillingham) and taught to small groups of four children.

Recent results from a three-city, federally funded (National Institute for Child Health and Human Development), randomized treatment-control study involve children who represented the most impaired readers in Grades 2 and 3. Children were randomly assigned to four treatment conditions and were controlled for socio-economic status (SES), race, and IQ. Each group received 70 hours of treatment throughout the school year.

We compared the effects of four types of treatment on an extensive battery of tests on all aspects of reading --- from accuracy and fluency in word attack to comprehension --- and on many language measures. The four treatments included two programs with multi-component emphases (RAVE-O and PHAST); one phonological-based program; and one control group who received regular classroom reading instruction. The PHAST program (Lovett et al, 2000) emphasized phonology, orthography, and morphology, but did not include the semantic and syntactic emphases in the RAVE-O program. The RAVE-O and the PHAST programs outperformed the control group on every measure. When compared to the systematic phonological analysis and blending treatment, the RAVE-O and PHAST groups again proved better on every measure. When compared only to PHAST, RAVE-O made similar significant gains on standardized measures of decoding, but superior gains on the GORT-3 Oral Reading Quotient, a combined fluency and comprehension score, and on measures of vocabulary and semantic flexibility (see overview in Morris, Lovett, Wolf, et al. in press). In other words, students who received instruction in programs that emphasized multiple dimensions of linguistic knowledge, performed equally well or better on every word attack and word identification measure (the specific emphases of the more unidimensional decoding treatment). Most importantly, RAVE-O with its additional emphases on semantic and syntactic development outperformed all other treatments in vocabulary and on the GORT fluency-comprehension measure.

The theoretical implications of these outcome data are critical. The premise of RAVE-O is that the plural linguistic emphases will enhance decoding, as well as vocabulary and fluent comprehension. The fact that RAVE-O instruction expends far less time on specific decoding skills and yet made comparable or superior gains in word attack and word identification to programs (which spent more of their instructional time on these skills) is compelling evidence
supporting the theoretical premise of RAVE-O: the more the child knows about a word, the faster and better the word will be decoded and understood.

In addition, and very importantly, this NICHD study demonstrated that impaired reading children could make significant gains in reading regardless of initial SES, race, or IQ factors (Morris et al., in press; Wolf et al., 2009). The latter set of results cannot be overemphasized. It suggests that despite these known impediments to achievement, the two multidimensional interventions produced similar gains in children from privileged and underprivileged backgrounds, regardless of IQ level or race. This result directly answers the question whether the linguistic demands in RAVE-O are too heavy for children in poverty or for children with lower cognitive aptitudes. We are well aware of Chomsky’s life-long concern with children from underprivileged backgrounds. We feel the results from the RAVE-O intervention program represent an important affirmation not only of her theoretical insights, but also of Carol Chomsky’s deeply held goals for all children.

In summary, the contributions of Carol Chomsky are hardly over. Researchers in child language and early reading have long been indebted to her for work concerning “invented spelling”, the importance of reading to young children, and syntactic development. Her most important insights, however, may be her least known till now: the critical contributions of all aspects of oral language to the development of reading, particularly for struggling readers. Our evolving interventions are daily testimony to the unfolding legacy of Carol Chomsky.

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