Reading and Assistive Technology: Why the Reader's Profile Matters

by Karen Erickson

Assistive technology (AT) can take many forms; however, as a support for reading, electronic text is a core feature of AT. Anderson-Inman and Horney offer a typology that describes the types of resources that can be used to vary the supportiveness of electronic text (Anderson-Inman & Horney, 1998; Horney & Anderson-Inman, 1999). The typology focuses on the function that each of the resources plays in the supported reading process (e.g., translational, explanatory, and illustrative) and is intended to serve as a conceptual framework that guides the selection of appropriate AT for students who struggle with reading. Table 1 shows a recent version of this typology as presented by Anderson-Inman and Horney (2007).

While the typography does fairly represent the range of supports that are possible given today's technologies, there is little research to guide its use with students with dyslexia. In general, research supporting the use of AT in reading for students with dyslexia is limited, and research to guide the selection of specific supports to meet individual student needs is even more limited. Yet, understanding the possible impact of AT on the reading skills of students with dyslexia requires that we move beyond questions regarding the use of AT generally or electronic texts specifically and focus on the impact that AT supports have on students with varying profiles of strength and weakness in reading.

AT, Reading, and Dyslexia

It is well understood that dyslexia is a specific learning disability that is neurological in origin and characterized by difficulties with accurate and fluent word recognition and decoding abilities. AT, specifically text-to-speech with electronic text, has long been recognized as an important reading

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TABLE 1. Abbreviated Version of Anderson-Inman and Horney's (2007) Typology of Resources for Supported Etext[1]

Resource	Description
Presentational	Allows for variations in the presentation of text and graphics including changes to font size and style, text and background color, line and page length, page layout and graphics layout
Navigational	Supports movement within and between documents via links, embedded menus, and links from other resources such as Table of Contents, Glossary, Bibliography
Translational	Provides one-to-one translation of words, phrases, paragraphs, graphics, or the entire document via synonyms, definitions, text-to-speech, alternate language equivalents (Spanish), reduction of reading level, text descriptions for images, captions for video
Explanatory	Clarifies the what, where, how, or why of concepts, objects, processes, or events via descriptions that point to causes, operations, components, mechanisms, parts, methods, procedures, context, or consequences; may also provide lists of influencing factor(s)
Illustrative	Provides visual representations and examples via drawings, photos, simulations, video, sounds, music, and other forms of information that something is representative of its type ("...is a typical example of...")
Summarizing	Provides a summarized or shortened view of some aspect of the document via a table of contents, concept map, list of key ideas, chronology, timeline, cast of characters, abstract
Enrichment	Offers supplementary information such as background information, publication history, biography of the author, footnotes, bibliography, influence on other writers
Instructional	Teaches some aspect of the text with instructional prompts, questions, strategies, tutorials, annotations, study guides, online mentoring, tips for effective reading
Notational	Supports note taking and marking up the text via electronic highlighting, bookmarking, margin notes, outlining, drawing along with a means of gathering and grouping notes for post-reading review
Collaborative	Supports working with or sharing with others via threaded discussion, online chat, e-mail links, podcasts, blogs
Evaluational	Provides a means of assessing student learning via questions, quizzes, tests, surveys, online interviews, assignments leading to products

Note. Adapted from "Supported eText: Assistive Technology through Text Transformations," by L. Anderson-Inman and M. A. Horney, 2007, *Reading Research Quarterly*, *42*(1), p. 154.

[1] An etext (from "electronic text") is, generally, any text-based information that is available in a digitally encoded, human-readable format and read by electronic means

solution for students with dyslexia (see, e.g., Abelson & Petersen, 1983; Anderson-Inman et al., 1990), and as technology has become ubiquitous, text-to-speech solutions are becoming commonplace. However, research regarding the use of AT to support reading for students with dyslexia has not kept pace with the development of the technology itself (Holmes & Silvestri, 2012).

Extant research supports text-to-speech solutions as a means of improving reading rates and comprehension for students with dyslexia (Elkind, 1993) and learning disabilities more broadly (Elkind, 1998; Montali & Lewandowski, 1996). For students with learning disabilities, text-to-speech has a positive impact on vocabulary (Elkind, Cohen, & Murray, 1993), phonological decoding and word recognition (Olson & Wise, 1992), and silent word reading and oral reading of text (Elbro, Rasmussen, & Spelling, 1996), and importantly, these skills transfer to improved reading skills with printed materials (Elkind, Cohen, & Murray, 1993). However, the impact of text-to-speech on reading rate and comprehension is not uniform. In a study of adults with severe reading disabilities, the impact of text-to-speech was greatest for individuals with the poorest silent reading skills (Elkind, Black, & Murray, 1996).

Higgins and Raskind (1997) investigated the supportiveness of text-to-speech for postsecondary students with learning disabilities. They found that the intervention led to gains in reading comprehension overall, but a more careful examination of the findings revealed that, like Elkind, Black, and Murray (1996), gains were greatest for students with the poorest silent reading ability without AT, and text-to-speech actually interfered with the reading comprehension of students with the best silent reading skills. This type of profile-based approach to understanding which students benefit from text-to-speech and other AT is important. Unfortunately, most of the research regarding AT to date fails to consider subtypes of learning disabilities (Holmes & Silvestri, 2012) and profiles of strengths and weaknesses in reading.

A Closer Look

Reading difficulties in students with dyslexia are often explained with respect to the Simple View of Reading (Gough & Tunmer, 1986), which suggests that reading ability can be explained by the combination of one's ability to identify written words and comprehend language (i.e., listening comprehension). Students with dyslexia, by definition, struggle with word identification, especially the phonological decoding aspects of word identification, and are believed to struggle with comprehension of text as a result of these difficulties in word identification. However, deficits in word identification often exist in the absence of difficulties comprehending text through listening. Furthermore, the difficulties students with dyslexia experience with reading comprehension may be influenced by deficits in other aspects of reading that extend beyond those reflected in the Simple View. Finally, profiles of relative strengths and weaknesses in reading are not static, especially if students are engaged in effective reading interventions that systematically target areas of need. As a result, the decisions we make about the use of AT to support reading should not be static.

Understanding the impact that AT can have on the reading success of students with dyslexia requires that we take a closer look at the profile of strengths and weaknesses presented by individual students and monitor that profile over time. It also requires that we consider their abilities in silent reading and listening comprehension in the absence of AT relative to the difficulty of the text they are being asked to read. If the text exceeds not only the student's silent reading ability but also the student's listening comprehension ability, text-to-speech will offer little support. Furthermore, until we start investigating Anderson-Inman and Horney's typology of resources (Anderson-Inman & Horney, 1998; Horney & Anderson-Inman, 1999) that vary the supportiveness of electronic text relative to these profiles of strength and weaknesses and abilities in silent reading and listening comprehension, we will not move forward in our understanding of how best to use AT to support reading for students with dyslexia.

A group of 51 students (36 were male) in grades 3–8 in one school system offers a concrete example of this point. The students were involved in a reading intervention program guided by an individually administered diagnostic reading inventory. The inventory identifies a student's profile of strengths and weaknesses and abilities in word identification, listening comprehension, and silent reading comprehension per the Whole-to-Part (WTP) model of silent reading comprehension (Cunningham, 1993). The 51 students all qualified for special education services because of a learning disability and the results of the individually administered diagnostic reading inventory suggests that they have difficulties with accurate and/or fluent word recognition and decoding abilities. They are the subgroup of students participating in the reading intervention program who have a profile of abilities consistent with dyslexia, and they help demonstrate why we must be more precise in considering profiles of individual students when making decisions about AT and when recruiting and describing participants in research. Before considering how their individual profiles and abilities can influence the impact of AT on reading, it is important to understand more about the WTP model.

The Whole-to-Part Model

The WTP Model of silent reading comprehension (Cunningham, 1993) begins with the assertion that reading comprehension requires word identification, language comprehension, and whole text print processing (i.e., silent reading fluency). Each of these integrated abilities is part of silent reading comprehension ability, yet each can be considered an independent whole that also is composed of its own parts. A diagnostic reading inventory based on the WTP model assesses a student's ability to identify words, listen with comprehension, and read silently with comprehension without looking back at the text when responding to questions.

TABLE 2. Grade of Record for Participants

3rd grade	4th grade	5th grade	6th grade	7th grade	8th grade
7 (13.7%)	14 (27.5%)	8 (15.7%)	4 (7.8%)	11 (21.6%)	7 (13.7%)

TABLE 3. Race/Ethnicity for Participants

Black/African American	White	Hispanic	Multi-Racial	Asian/Pacific Islander
7 (13.7%)	29 (56.9%)	13 (25.5%)	1 (2.0%)	1 (2.0%)

Word identification is the cognitive process of making print-to-sound links to translate both familiar and unfamiliar printed words into pronunciations (Cunningham & Cunningham, 1978; Perfetti, Bell, & Delaney, 1988; Van Orden, Johnston, & Hale, 1988). For students with dyslexia, word identification vocally, subvocally, or neurologically, is the component of reading that is consistently impaired. In contrast, language comprehension, which involves knowledge of the world and processing of text structures, is not always impaired. Students with dyslexia often have deep knowledge of the world or background knowledge and experience related to the topics assumed by a text's author. Furthermore, they are often quite successful in accessing knowledge of text structures including syntax, cohesive ties, and organizational or genre patterns (Frank, Grossi, & Stanfield, 2006) to support comprehension through listening. In contrast, students with dyslexia often struggle with the final component of the WTP model, whole text print processing, because they have had limited successful experience with the silent reading practice that is required to build these skills. Specifically, whole text print processing is composed of at least five parts: 1) eye-movement strategies (see, e.g., Rayner & Pollatsek, 1989); 2) inner speech (see, e.g., Daneman & Newson, 1992; Slowiaczek & Clifton, 1980); 3) print-to-meaning links (see, e.g., Van Orden, 1991); (4) prosody projection (see, e.g., Cowie, Douglas-Cowie, & Wichmann, 2002); and 5) integration. Each of these parts can only be developed through successful silent reading practice. As such, students with dyslexia typically struggle with these parts of reading.

Why Profiles Matter

Data from the following study provides a good example of why learner profiles are so important. The 51 students who participated in the system's reading intervention each completed the individually administered diagnostic assessment to determine their profile relative to the WTP model. As such, each student's grade level equivalent in word identification, listening comprehension, and silent reading comprehension was assessed directly. To provide a more complete picture of the group of students, their grade of record and race/ethnicity is provided in Tables 2 and 3 respectively.

Table 4 offers a snapshot of the word identification, listening comprehension, and silent reading comprehension skills of these 51 students relative to their grade of record. These are precisely the students to whom we try to provide assistive technologies to support their reading, yet their reading profiles suggest that they require different types of technologies.

If we examine the whole group of 51 students, the relative weakness in word identification coupled with listening comprehension skills that are slightly above grade level would suggest that the group would benefit from text-to-speech access to grade-level text; however, there is great variation within the group that cannot be ignored. This variation may explain why the extant research regarding AT to support reading for this population is equivocal.

The WTP profiles of these 51 students help us understand that 33 can listen with comprehension at or above grade level and would likely benefit immediately from access to digitized text and text-to-speech. The remaining 18 students struggle to identify the words and also struggle to understand text when others read it to them. These 18 students listen with comprehension one or more grade levels below their grade of record. Certainly, text-to-speech would provide them with support in identifying the words, but it would do little to support their understanding of the text. Perhaps the addition of some of the

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TABLE 4. Number of Years below Grade Level in the Components of the WTP

	Word Identification	Listening Comprehension	Silent Reading Comprehension
At or above grade level	2 (3.9%)	33 (64.7%)	21 (41.2%)
1 grade level below	8 (15.7%)	10 (19.6%)	10 (19.6%)
2 grade levels below	23 (45.1%)	6 (11.8%)	17 (33.4%)
3 or more grade levels below	18 (35.3%)	2 (4.0%)	3 (5.9%)
Mean (standard deviation)	2.29 (1.08)	-.1176* (1.72)	.8088 (1.21)

*note: the group listens with comprehension slightly above grade level.

support features highlighted in Anderson-Inman and Horney's typology could be added to allow these 18 students to comprehend more successfully. For example, *explanatory* resources might clarify the meaning or *instructional* resources might teach critical concepts. However, the resources that are highly supportive for those students who are only 1 year behind are unlikely to provide enough support for students who are 3 or more years behind grade level in their ability to listen with comprehension. These students may require resources that are *translational* and simplify the text or *illustrative* and offer visual or multimedia representations of the text.

Interestingly, 21 of the students (41.2%) read text silently with comprehension at a level that exceeds their ability to decode words in isolation. These students are likely using strong language comprehension and print processing skills to determine the meaning of text and decode individual words that they cannot decode out of context. This may be the type of reading profile exhibited by the participants in the two studies (Elkind, Black, & Murray, 1996; Higgins & Raskind, 1997) that found that text-to-speech was most beneficial for students who had the lowest silent reading skills. Looking at the profiles for the 21 students in this study, it is possible the text-to-speech interferes with the processes they are currently using to silently read and understand text without pronouncing each of the words.

Summary

Carefully considering a student's complete profile is not only beneficial at the level of the individual student, but it is imperative that research on the use of AT in reading report not just a disability label, global reading score, or word identification score for the participants in the study. We must stop asking, "Is AT effective?" and start asking, "Which students benefit from this AT?" and "Which combination of supports is best?" Responding to these questions requires that we more carefully describe the reading profiles of research participants.

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***Karen Erickson, Ph.D.**, is the Director of the Center for Literacy and Disability Studies, the David E. and Dolores J. Yoder Distinguished Professor of Literacy and Disability Studies, and a professor in the Division of Speech and Hearing Sciences at the University of North Carolina at Chapel Hill. She is a former teacher of children with disabilities and currently studies literacy assessment and instruction for all students.*