From Illegible to Understandable

How Word Recognition and Speech Synthesis Can Help

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Thomas was a 9-year-old third-grade student who attended a small private school for students with learning problems. He had a severe learning disability in reading and writing, as well as an attention deficit disorder. Despite above-average intelligence and good verbal skills, Thomas read at a first-grade level. Although he had a lot to say when he dictated, his spelling was so poor that his writing was usually unreadable even to himself and his teacher (see Figure 1). Thomas's math skills were average, and he had a keen interest in computers.

The reading instruction program designed for Thomas and his classmates included systematic instruction in phonics, reading and discussion of trade books, and story listening and retelling activities. The class wrote in dialogue journals about twice a week.

The speech synthesis helped Thomas to read his teacher's messages without asking for help.

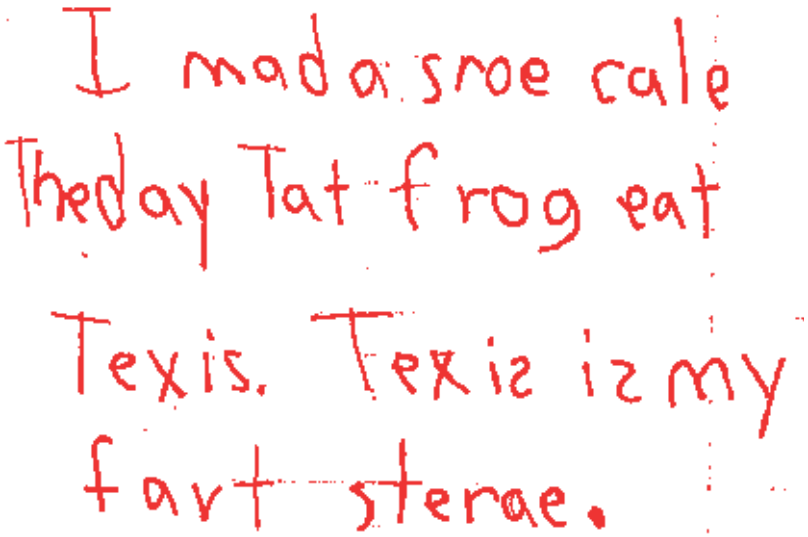
Speech synthesis and word prediction capabilities complemented the teachers' attempts to model appropriate written language.

Using Dialogue Journals

Dialogue journals are written conversations between the teacher and each individual student (Staton, Shuy, Kreeft-Peyton, & Reed, 1988). Dialogue journals provide an opportunity for teachers to model language usage and written form without directly correcting student language. Students can draw on the teacher model and their own oral language competence to construct written language that serves an immediate and personal purpose.

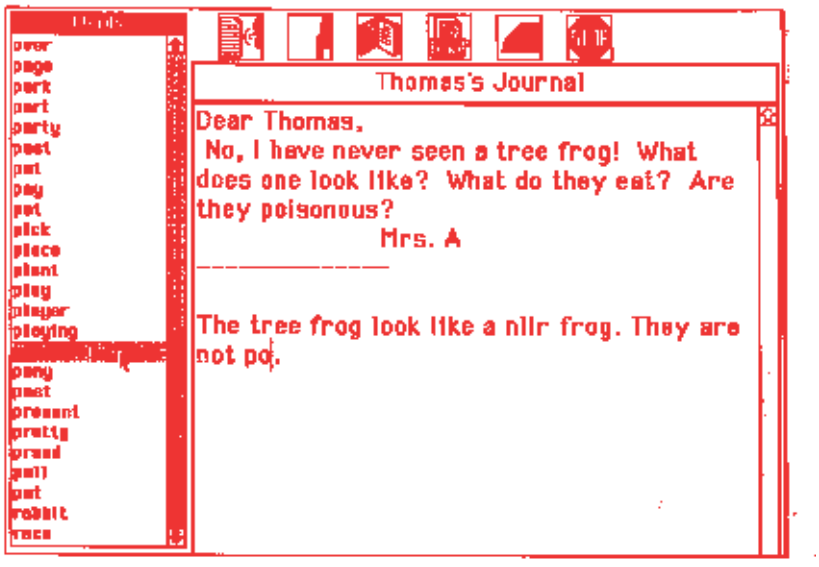
Before the class began using computers for their journals, the teacher would

Figure 1
Thomas's Handwriting



Handwritten composition by Thomas. (I made a story called, "The Day That Frog Ate Texas." Texas is my favorite state.)

Figure 2
My Words



Thomas has typed the first two letters of "poisonous"; the word list has scrolled to the first word beginning with those letters; and Thomas is about to double-click on the word to insert it in his text.

either take dictation for Thomas or have him write first and then write her own translation at the bottom of the page. Word processing was introduced into the class, and Thomas enjoyed using the computer, but it did not provide sufficient help since his spelling errors were too severe for a spelling checker to help.

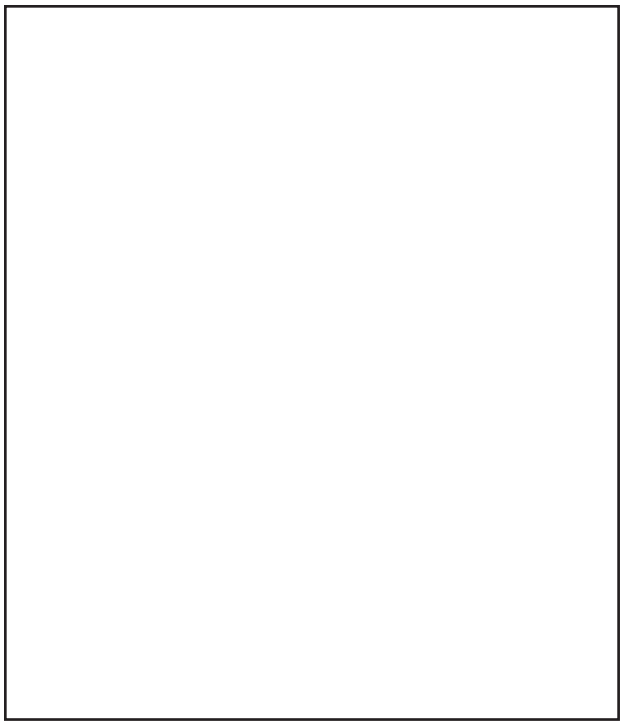
The following is a sample exchange between Thomas and his teacher written with a conventional word processor:

> Dear Thomas,
>
> What was your favorite Christmas present? I enjoyed it when you read *Amelia Bedelia* to the class. What book are you going to read next?
>
> Mrs. A
>
> [Thomas's response]. The Redr was my fart croms past. it a ras car Im go to red the sooc oid tree to the littl kers.
>
> good bay
>
> [Translation: The Red Ranger was my favorite Christmas present. It's a race car. I'm going to read the *Spooky Old Tree* to the little kids. Good bye.]

Thomas Uses Word Prediction and Speech Synthesis

Midway through the school year, Thomas and some of his classmates, as part of a research study, began to use a word processor that included speech synthesis and limited word prediction capabilities (*My Words*, 1993). Speech synthesis translates words typed by the user into speech. The speech synthesis helped Thomas to read his teacher's messages without asking for help. It also allowed him to have the computer read all or part of his writing. As he listened to his writing, he could pick up errors that he would miss just by reading.

Word prediction programs were originally developed to reduce typing for individuals with physical disabilities. These programs "predict what word the user intends to write based on the first letters typed. Thus, the user can type the first letter, or first few letters, and then choose from a list of predictions instead of typing the whole word. Word prediction may also help students like Thomas who have severe spelling problems.



Four of the five students in the study increased both their percentage of legible and correctly spelled words into the 90% to 100% range.

My Words makes its predictions from an alphabetical word list that is visible on the screen. As Thomas typed the first letter(s) of a word, the word list automatically scrolled to the first word beginning with that letter(s) (see Figure 2). He could click on the word in the list to insert it in his story. He could also hear the word pronounced by the speech synthesizer before selecting it.

Speech synthesis and word prediction complemented the teachers' attempts to model appropriate written language. Speech synthesis supported Thomas in reading the teacher's entry fluently and in catching his errors in spelling and sentence formation. Word prediction supported correct spelling and expanded vocabulary usage. When Thomas began using the program, the teacher entered about 300 common first-, second-, and third-grade spelling words to the list. In addition, every word used by the teacher was added to the dictionary in the word-prediction software, and words used by the student appeared in the dictionary with their spelling corrected by the teacher. Thus, all the vocabulary used in the dialogue journal was available for easy use by the student in responding to the teacher.

Computer support permitted Thomas to participate more independently in an important writing activity.

Here is an entry using the new program:

> Dear Thomas,
>
> Since the weather has gotten nicer, have you seen any frogs or toads?
>
> Mrs. A
>
> [Thomas's response.] Yes. Frogs are fast. I can allmost
>
> catch a frog. I see tiny tadpoles.
>
> Dear Thomas,
>
> What kind of frogs do you like? I don't know if I like them. They seem a bit scary. Have you ever had a pet frog?
>
> Mrs. A
>
> [Thomas's response.] My favorite frog is a poisonous dart frog. I have catch frogs. Frog are helpful.

What Thomas Did

The computer support permitted Thomas to participate more independently in an important writing activity. It enabled him to continue to develop skills in communicating ideas in writing despite his severe spelling deficit. These writing activities also supported his growth in reading; he could read back through his journal using the speech synthesis to help him figure out unfamiliar words.

For Thomas, however, use of the software did not lead to improved spelling without the support of the program. When he wrote without the speech synthesis and word prediction, his writing demonstrated no improvement in spelling. Additional instruction would be needed to help Thomas to make the transition to using a standard word processor with a spelling checker.

Learning from Thomas

Thomas was one of five students, with learning disabilities and severe writing problems, ages 9 and 10, who participated in a study of word prediction and speech synthesis (MacArthur, 1997a). The study used a multiple-baseline design with withdrawal. Students used a standard word processor during baseline phases and a word processor with speech synthesis and word prediction features during treatment phases.

The special features had a strong effect on the legibility and spelling of written dialogue journal entries for four of the five students in the study. During baseline, the writing of these four students ranged from 55% to 85% legible words and 42% to 75% correctly spelled words. All four increased both their percentage of legible and correctly spelled words into the 90%-100% range. Performance returned to baseline levels when students returned to using the standard word processor. Thus, the program provided compensatory support but in the short run, at least, did not result in improved independent spelling skill.

The results demonstrate the potential of word prediction and speech synthesis as assistive technology for some students with severe problems in basic writing skills. The study should not be interpreted as supporting the use of word prediction and speech synthesis, however, by all or even most students who struggle with basic writing skills. Research on word prediction and speech synthesis (see box, "Annotated Bibliography") is very limited, and little is known about the conditions under which these assistive technology tools are helpful. Decisions about the use of assistive

technology for writing should take into account the capabilities and needs of individual students and the demands of the writing tasks.

Critical Issues

One critical issue is the match between the support provided by the assistive technology and the requirements of the writing task and context. In the study with Thomas, the word prediction software used a relatively small dictionary, or word list, that was closely matched to the topics and vocabulary used in each individual student's dialogue journal. The small vocabulary simplified the task of the students in selecting the intended word from the possibilities in the word list.

Another study, currently under analysis (MacArthur, 1997b), suggests that word prediction programs with larger dictionaries are more difficult for students with LD to use and only improve students' writing when the writing task requires that larger vocabulary. Thomas and his classmates learned to use *My Words* relatively quickly with just 2 or 3 sessions of demonstration and guided practice.

Students in the second study learned to operate the functions of the more sophisticated program but experienced continuing difficulty in getting the program to predict the words that they intended. Younger students may find it easier to use versions of word prediction with limited dictionaries and simple interfaces like *My*

Dialogue journals provide an opportunity for teachers to model language usage and written form without directly correcting student language.

Annotated Bibliography on Speech Synthesis and Word Prediction

Borgh, K., & Dickson, W. P. (1992). The effects on children's writing of adding speech synthesis to a word processor. *Journal of Research on Computing in Education, 24,* 533-544.

Compared word processing with and without speech synthesis with nondisabled second- and fifth-grade students. Students did more revising after each sentence with the speech synthesis and less revising at the end. No differences were found in length or quality of writing.

Lewis, R., Graves, A., Ashton, T., & Kieley, C. (1996, April). *Text entry strategies for improving writing fluency of students with learning disabilities*. Paper presented at the annual meeting of the Council for Exceptional Children, Orlando, FL.

Reported that students with learning disabilities who had modest experience writing with a computer produced text slightly faster with word prediction (with the speech synthesis turned off) than with typing, but still more slowly than with handwriting. These results, however, might well differ given more practice with keyboarding.

MacArthur, C. A. (1996). Using technology to enhance the writing processes of students with learning disabilities. *Journal of Learning Disabilities, 29,* 344-354.

Reviewed ways that technology can support writing processes, including basic transcription and sentence generation, planning and revising processes, and collaboration and communication.

MacArthur, C. A. (1997a). *The effects of word processing with speech synthesis and word prediction on the dialogue journal writing of students with learning disabilities.* Manuscript submitted for publication, University of Delaware.

The study from which the case of Thomas was taken.

MacArthur, C. A. (1997b). [Two studies on word prediction and speech synthesis with students with severe writing disabilities]. Unpublished raw data.

Students alternated use of a sophisticated word prediction program with a 10,000-word vocabulary and speech synthesis, a standard word processor, and handwriting. The initial study found no differences between conditions, but a subsequent study using a writing task requiring a larger vocabulary found a positive impact of word prediction on spelling and legibility for 2 of 3 students.

MacArthur, C. A., Graham, S., Haynes, J. A., & De La Paz, S. (1996). Spelling checkers and students with learning disabilities: Performance comparisons and impact on spelling. *Journal of Special Education, 30,* 35-57.

Study 1 compared the performance of common spelling checkers on misspellings made by students with learning disabilities. Study 2 compared the performance of students with learning disabilities with and without a spelling checker. Overall, students corrected 37% of their errors with a spelling checker.

Newell, A. F., Arnott, J., Booth, L., Beattie, W., Brophy, B., & Ricketts, I. W. (1992). Effect of "PAL" word prediction system on the quality and quantity of text generation. *Augmentative and Alternative Communication, 8,* 304-311.

Case study reports indicating that word-prediction software can improve spelling, increase the quantity and quality of writing, and enhance motivation among students with a range of disabilities including learning disabilities and language delays, as well as physical disabilities.

Raskind, M. H., & Higgins, E. (1995). Effects of speech synthesis on the proofreading efficiency of postsecondary students with learning disabilities. *Learning Disability Quarterly, 18,* 141-158.

Compared three revising conditions with college students with learning disabilities: speech synthesis, reading aloud by a human, and no assistance. Overall, students found the greatest proportion of errors using speech synthesis (35%), followed by the human reader (32%) and no assistance (25%). The report did not provide data on the number of errors actually corrected, only on errors found.

Words. Students who require larger vocabularies will need to use more sophisticated programs like Co:Writer (see Table 1). Teachers should recognize that more instruction is needed to use more sophisticated programs effectively.

Before deciding to use word prediction and speech synthesis, teachers should consider the available alternatives for supporting basic writing skills, including both other assistive technologies (MacArthur, in press), such as word processing with spell checking or dictation using voice recognition, and nontechnological options, such as invented spelling, dictation to an adult, or personal dictionaries.

The most common and generally useful assistive technology for basic writing skills is spell checking. In comparison to spelling checkers, word prediction has both potential advantages and limitations (MacArthur, Graham, Haynes, & De La Paz, 1996). Students whose misspellings are too severe for correction by a spelling checker may benefit from word prediction. Word prediction does not require a user to type the entire word; consequently, knowing just the first one to three letters may be sufficient for an accurate prediction of many words. On the other hand, word prediction programs are not designed specifically to support spelling. The user must spell the beginning of the word correctly, with no allowance for phonetic substitutions. Perhaps more important, word prediction places a substantial burden on working memory because it requires the user to attend to spelling while writing rather than afterwards.

Given these advantages and limitations, it seems likely that word prediction would be most useful for writers with severe spelling problems (or, of course, those with physical disabilities). Students whose writing is readable would probably do better with a spelling checker, which allows writers to focus on content while writing and fix errors later. Writers who are extremely reluctant to produce any text because of spelling problems may be willing to attempt writing with word-by-word support. For writers like Thomas whose spelling is so poor that their text is unreadable even by a sympathetic teacher or by themselves a day after it is written, word prediction may offer a more independent alternative than dictating to an adult.

Word prediction programs "predict" what word the user intends to write based on the first letters typed.

Table 1
Word-Prediction Software

Aurora
(Word prediction based on spelling, word relationships, and frequency of use; speech synthesis. DOS, Windows 3.1, and Windows 95)
Aurora Systems
2647 Kingsway
Vancouver, B.C. V5R-5H4
Canada
(604) 436-2694
http://www.djtech.com/Aurora/

Co:Writer
(Word prediction based on spelling, word relationships, grammar, and frequency of use; speech synthesis. Macintosh)
Don Johnston Developmental Equipment
P.O. Box 639
1000 North Rand Rd., Bldg. 115
Wauconda, IL 60084-0639
(800) 999-4660
http://www.donjohnston.com/

EZ Keys
(Word prediction based on spelling, word relationships, and frequency of use; speech synthesis. DOS only.)
Words + Inc.
43700 17th St. West, Suite 202
P.O. Box 1229
Lancaster, CA 93584
(800) 869-8521

HandiWORD
(Word prediction based on spelling and frequency of use, DOS and Windows)
Microsystems Software, Inc.
600 Worcester Rd.
Framingham, MA 01701
(800) 828-2600

My Words
(Word prediction based on spelling only, speech synthesis; Macintosh)
Hartley Courseware
133 Bridge St.
Dimondale, MI 48821
(800) 247-1380

Telepathic 2.0
(Word prediction based on spelling, grammar, and frequency of use; speech synthesis; Macintosh and Windows)
Madenta Communications Inc.
9411A - 20 Ave.
Edmonton, Alberta
T6N 1E5, Canada
800-661-8406
http://madenta.com/

Spelling Still Important

An important limitation of both word prediction and spell checking is that neither appears to have much impact on students' independent spelling skills, at least in the short run. When Thomas and his classmates returned to using the standard word processor, their performance declined to baseline levels. Thus, along with these assistive technologies, teachers need to provide instruction in spelling

Decisions about the use of assistive technology for writing should take into account the capabilities and needs of individual students and the demands of the writing tasks.

and other basic writing skills. In addition, teachers and instructional designers could work on the development of instructional methods that integrate instruction in basic skills with assistive technologies.

For example, students could learn strategies for finding the correct spelling with a spell checker or word prediction by attempting alternative spellings until the program is able to suggest the correct word. Such problem-solving activities might generalize to independent spelling ability.

References

MacArthur, C. A. (in press). Overcoming barriers to writing: Computer support for basic writing skills. *Reading and Writing Quarterly.*

MacArthur, C. A. (1997a). *The effects of word processing with speech synthesis and word prediction on the dialogue journal writing of students with learning disabilities.* Manuscript submitted for publication, University of Delaware.

MacArthur, C. A. (1997b). [Two studies on word prediction and speech synthesis with students with severe writing disabilities]. Unpublished raw data.

MacArthur, C. A., Graham, S., Haynes, J. A., & De La Paz, S. (1996). Spelling checkers and students with learning disabilities: Performance comparisons and impact on spelling. *Journal of Special Education, 30,* 35-57.

My Words [computer program]. (1993). Dimondale, MI: Hartley.

Staton, J., Shuy, R. W., Peyton, J. K., & Reed, L. (1988). *Dialogue journal communication: Classroom, linguistic, social and cognitive views*. Norwood, NJ: Ablex.*

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Photographs by Bob Cohen, University of Delaware.