A Preliminary Investigation of the Benefits of Computer-Aided Instruction in Reading Decoding for Students with Autism Spectrum Disorder and Other Developmental Disabilities

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Abstract

For students who have limited expressive language skills, both verbally and in writing, it is difficult for a teacher to assess the acquisition of reading skills. The authors examined the effects of computer-aided instruction (CAI) on the early reading and reading comprehension skills of six students with autism spectrum disorder, and other developmental disabilities during four weeks in an extended school year (ESY) services classroom setting. The purpose was to examine Headsprout Early Reading™ and Headsprout Reading Comprehension™ as an intervention to supplement instruction and assess early reading skills and make recommendations for use during the regular school year. While three students made progress in the program, focus and ability to attend impacted results with the other three.

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Research indicates that systematic instruction in five core elements of reading (phonemic awareness, alphabetic principle, oral reading fluency, vocabulary, and comprehension) facilitates the building of competent readers (National Institute of Child Health and Human Development, 2000). Print awareness, knowing that text is read or followed from left to right and top to bottom, is also important (Huffstetter, King, Onwuegbuzie, Schneider, & Powell-Smith, 2010). All students must have access to appropriate reading curricula and instruction in order to develop a society that is literate (Whitcomb, Bass & Luiselli, 2011). Identifying reaserch-based curricula for teaching students when the students have autism spectrum disorder (ASD) and other developmental disabilities (DD) that make reading progress difficult to measure, is necessary to comply with legistlative mandates such as No Child Left Behind (2001). Teachers have struggled to identify appropriate curricula for students with ASD and DD, especially for those with limited (or without) verbal communication skills and/or limited use of sign language and assistive technology communication devices, making it difficult to measure reading acquisition and progress. It is often difficult to determine if these students are identifying words, learning to read, or comprehending what they read.

Several published findings regarding computer-aided instruction have been published in the United States and abroad for students with ASD and DD. Colby (1973) conducted one of the earliest attempts to stimulate language development through computer instruction for 17 children with autism who were non-verbal, showing positive gains in motivation to participate in computer instruction and use of some voluntary speech. Panyan (1984) reviewed computer use

for students with ASD, finding that computers could be used to improve interaction and in other areas as well. Clarfield and Stoner (2005), investigated the use of Headsprout™ as a beginning reading intervention for 3 boys (grades K-1) with ADHD and focused on oral reading fluency and task engagement using a multiple baseline design with successful outcomes (compared to teacher-directed instruction).

The use of computer-aided instruction (a technology-based treatment intervention) that adapts to students needs and provides educators with real-time accurate information on reading progress (Simba Information, 2009) has been identified as an emerging treatment worthy of additional research, according to the National Autism Center (2009). The goal of this project is to investigate the use of a data-based, computer-assisted reading program that targets the 5 essential elements of reading (phonemic awareness, alphabetic principle, oral reading fluency, vocabulary, and comprehension), and monitors student progress through the curriculum (Layng et al., 2003; Twyman et al. 2005). It is an important goal of this study to investigate whether Headsprout is such a program designed using behavior analytic principles to accelerate early reading skills for students in preliminary grades (Whitcomb, Bass, & Luiselli, 2011).

The purpose of this study was to a) determine whether a computer-aided data based program would assist students with ASD and DD to identify words with the goal of learning to read beyond instruction typically provided in the classroom, and b) facilitate outcome measurement for teachers evaluating reading progress for students with ASD and DD, for whom traditional methods to measure reading acquisition and comprehension has often been difficult.

Traditionally, students with moderate and severe developmental disabilities (DD) have not received instruction in reading decoding; the emphasis of instruction has been functional reading and sight-based instruction (Katims, 2000). In a comprehensive review of reading research for students with moderate and severe DD, Browder, Wakeman, Spooner, Ahlgrim-Delzell, and Algozzine (2006) found that the majority of research in this area is related to sight word instruction with few studies involving code-based instruction. However, researchers have recently advocated for a change in instruction for students with moderate and severe intellectual disabilities. Bowder et al. (2009) describe a new framework for reading instruction that includes decoding and emphasis on literacy and independence. Research has shown that students with moderate and severe intellectual disabilities benefit from decoding instruction. Flores, Shippen, Alberto, and Crowe (2004) taught elementary students with moderate DD to decode CVC (consonant, vowel, consonant; e.g., bat, dog) words using portions of a Direct Instruction (DI) decoding program. Bradford, Alberto, Shippen, Houchins, and Flores (2006) taught middle school students with moderate intellectual disabilities decoding skills using Direct Instruction. Based on these initial findings, there is a need for additional research related to decoding instruction for students with moderate and severe DD.

In a 2005 study using CAI, a student with autism achieved mastery fastest using CAI when compared to teacher instruction (Coleman-Martin et al.). Children with autism may benefit from reading interventions using CAI since students with ASD often prefer solitary activities, have trouble making eye contact, and have poor expressive and/or receptive language skills, making participation difficult for them in reading groups with others, or in one-to-one lessons with adults (Boutot & Myles, 2011). While statistical significance is important for researchers, instructional

significance is of practical value for educators seeking interventions for students with significant disabilities (Twyman, Layng, and Layng, 2011). Therefore, the present study was undertaken to investigate the benefits of CAI for reading decoding in students with significant ASD and DD.

Materials

Headsprout™ targets the early reading needs of students K-2 (Headsprout™ *Early Reading*) and reading comprehension for students in grades 3-5 (Headsprout™ *Reading Comprehension*) focusing on reading comprehension as defined by knowledge of vocabulary and active use of multiple comprehension strategies and real-time assessment of progress (Simba Information, 2009). This interactive software program consists of 80 online lessons for *Early Reading* and 50 online lessons for *Reading Comprehension,* each lasting approximately 20-30 minutes (Leon, Layng, & Sota, 2011). The goal of the present study was to expose students to lessons each day during a 20 day program and assess outcomes for these students. Explicit instruction in phonics and phonemic awareness (including segmenting and blending), sounds fluency building exercises, building sight word vocabularies, and cues to punctuation are all incorporated into the Headsprout™ program (Clarfield & Stoner, 2005). Reading comprehension, oral reading with sound elements, vocabulary, print awareness, and deriving meaning from text are also embedded in the program and are known predictors of reading achievement (Huffstetter et al., 2010; Layng, Twyman, & Stikeleather, 2003). Nine patented teaching routines (Table 1) are incorporated into Headsprout™ early reading and include a component that adapts to the strenths/weaknesses of individuals students (Doe, 2005). Headsprout™ *Reading Comprehension* targets specific strategies for reading comprehension (e.g., literal, inferential, main idea and vocabulary) which are sytematically and explicitly taught. During development testing with 150 learners, consistent progress was demonstrated, and more than 35,000 school users have been taught these skills through Headsprout™, according to the developers (Leon, Layng, & Sota, 2011). The Florida Center for Reading Research selected Headsprout™ because it is (a) designed for independent use without intensive teacher supervision, (b) does not require a beginning reading vocabulary, and (c) requires less teacher training. In an initial study, researchers found that children entering kindergarten who completed 80 episodes reached an average grade equivalent of 2.1 on the Woodcock-Johnson Word Identification subtest (Layng, Twyman, & Stikeleather, 2003). The What Works Clearingouse (WWC) found that this study met their evidence standards based on doctoral research (2009). Another study found that seven of nine participants with dyslexia improved oral reading fluency performance. All parents involved in the study indicated high satisfaction with the Headsprout™ *Early Reading* program (Wochos, 2011).

Table 1
Nine teaching routines of Headsprout™ Early Reading

Routine	Description
Establishing	Teach sound-letter correspondence and sight words through explicit instruction
Adduction	Teach skills through a discovery learning method
Vocal Potentiation	Teach speaking out loud and becoming one's own listener
Blending and Segmenting	Teach blending sounds together into words and segmenting words into their individual sounds
Sentence and Story	Teach skills such as reading from left to right and reading for meaning
Fluency	Involve guided, timed reading practice
Motivation	Involve both extrinsic and intrinsic reward components
Application	Apply skills and strategies to new words, stories, and contexts
Overall Sequencing	Develop an interlocking set of skills and strategies and to allow to begin reading quickly

Method

Participants

Students between the ages of 9 and 14 enrolled in a university extended school year (ESY) summer program were the participants in the study. Computer-aided decoding instruction was incorporated into the curriculum for use as a literacy intervention. The typical schedule for all students enrolled in the program included three hours a day, five days a week instruction for four weeks, with a daily schedule that included direct reading instruction, discrete trial teaching, math, social skills, incidental teaching, and snack. The classroom had a lead teacher (master's student who was a full-time teacher) and 3 other adults (2 undergraduate students and a school district employee). There were 8 students assigned to the classroom. Two of the students in the classroom were successful verbal readers (although below grade level) and communicators and not part of the Headsprout™ intervention. The 6 students selected for participation are described in the paragraphs that follow.

Amy was a 9-year old Latina female with autism. Her IEP goals included increasing reading comprehension and communication. She communicated using a Dynavox™, pictures, or spoke using one word responses. In the area of reading, she was able to segment simple words into phonemes, identify consonant-vowel-consonant patterns in words, read and respond to simple sentences describing actions, sequence 3-4 events in a story and read color and number words. Her overall Test of Language Devlopment Score (TOLD) was a standard score of 48 at the time of the study.

Josiah was an 11 year-old White male with ASD. He was able to consistently and accurately isolate initial and final sounds in phonemic tasks, identify all consonant and vowel sounds and label real life objects. He was working on identifying the first event in a story read out loud and reading high frequency words. He had not mastered blending letter sounds into one-syllable words, matching 2-3 letter blends with their most common sound, reading regualar one-syllable words with fluency, and identifying events from a story. Josiah spoke using single words or used a speech-output device (Dynavox™). Josiah's overall TOLD score was a standard score of 44.

Jack was a 10 year-old African-American male with ASD. Jack could match some letter sounds to objects. He would benefit from instruction to develop phonemic awareness to blend and read words. He communicated using pictures and the iPad™ to request snacks and to use the restroom. He often cried when he frustrated, tired, or not feeling well. His overall TOLD score was a standard score of 43.

Misty was a 10 year-old White female with ASD. She identified letters and sounds and matched pictures to the correct beginning sound. She had difficulty demonstrating phonemic awareness (blending sounds to reading words). Misty used some single words and will, at times use three word requests. She also used pictures to communicate. Her TOLD score at the time of this study was a standard score of 43.

Adelle was a 12 year-old African-American female diagnosed with DD including cerebral palsy, epilepsy, hydrocephalus, and visual impairment. She was working on letter identification, segmenting and spelling 3 letter words using cards, basic comprehension and sequencing skills.

She had difficulty writing and her parents desired a move toward typing in lieu of writing . She had difficulty staying on task. Her TOLD score was a standard score of 42.

Connie was a 14 year-old White female diagnosed with ASD. She could read sight words and short sentences. She was able to answer "wh" questions about books read with an familiar adult. She used her speech-output device (Dynavox™) to spell some words when asked. Her TOLD score was a standard score of 55.

Prerequisite reading skills were assessed to determine the appropriate reading intervention (Headsprout *Early Reading™* or Headsprout *Reading Comprehension™*). Headsprout *Early Reading™* is used to build the necessary reading skills before beginning the reading comprehension program. The goal of the program was to provide students with computer-assisted reading instruction during ESY services that can be easily transferred to the home school where the intervention could be continued, providing continuity of reading instruction and data collection procedures. Pre-test/post-test data were collected using the Headsprout™ Readiness Assessment.

Results

Students accessed Headsprout™ during the time allocated for direct reading instruction. The teacher worked with each student individually at first to assess pre-requisite computer skills, and introduced each student to the structure of the program and the episode indicated by the pre-test, if applicable. The results of successful Headsprout™ *Completed Episode Performance* data as well as the adult assistance required are indicated in the following paragraphs.

Amy initially needed redirection to stay with the Headsprout™ *Early Reading* program. If left unattended, she would exit the program and enter another familiar game program. As she progressed through Headsprout™ she began to request to use Headsprout™ as a reinforcer choice, and there were no further attempts to exit the program during use. Amy was placed in episode 57 to begin Headsprout™ as recommended by the results of her pretest score. Amy completed the *Early Reading* program in 7 school days (episodes 57 to 80), scoring between 91% and 99% on all 23 episodes. Amy moved to Headsprout™ *Reading Comprehension* for the remainder of ESY services, completing 9 lessons. Scoring for reading comprehension is different than in Early Reading. The printout showed scores over 75% in green, scores between 50-74% in purple, and scores below 50% in red. Most of Amy's scores were purple (50-74%) for the first 4 lessons, perhaps because she was getting used to the format of the new program. She scored in the green range (greater than 75%) for 11 of 13 areas for lessons 5-8. In lesson nine, she had red scores (below 50%) in questions regarding main idea, inferences, and in total correct first attempts. It would be recommended that she restart this lesson and try again. Lesson 9 focused on strategy application, which was not part of lessons 1-6. Amy was able to complete the post-test increasing her words read correctly from 85 to 147 (significant for a four week intervention!). Amy was the only student to complete *Early Reading* and move into Headsprout™ *Reading Comprehension.* The other five students began and ended the study using the Headsprout™ *Early Reading* program.

As a result of the pre-test, Josiah began at lesson one and progressed through lesson eight in Headsprout™ *Early Reading*. He scored above 80% on lessons 1,3, and 6. He scored between 70-79% for the other 5 lessons. Josiah was able to work independently and did not require redirection. Josiah accessed the computized lessons over 24 sessions.

Jack also began Headsprout™ *Early Reading* at the first lesson. He was unable to read any words during the pretest or post-test. Jack had difficulty attending to the program and would not engage, even when prompted by an adult. He completed 2 lessons over 7 sessions. While his scores were above 80% for both lessons at completion, he had a large number of timeouts (opportunities to click but did not) during the first 4 attempts at Headsprout™ *Early Reading*. The percent of timeouts declined sequentially over the course of the 7 sessions, going from 66% to 9%, which could mean he was beginning to independently engage and attend to the program toward the end of ESY services.

Misty also began Headsprout™ *Early Reading* at the first lesson. She did not read any words correctly during the pretest or post-test, and it was difficult to ascertain if she were attending to the reading material. She did not appear to look at or directly attend to the words she was asked to read during the two minute pretest. Misty needed one-to-one adult supervision to stay focused and to click on the answers using the mouse while using Headsprout™. She had 5 sessions with Headsprout™ *Early Reading* during the ESY period. It is of note that she also had a high percentage of timeouts (opportunities for the learner to click but did not) which reduced significantly during the sessions and ranged from 94% to 46% (indicating that she was responding more freqently to program prompts resulting in fewer timeouts).

Adelle began at lesson one of Headsprout™ *Early Reading* since she was unable to read any words during the pretest. She was able to complete 2 lessons over the course of 10 sessions. She completed lessons 1-2 and began lesson 3 at the end of the ESY program.The teacher reported that unless one-to-one supervision (often with hand over hand support) was utilized, Adelle did not demonstrate an ability to focus on the task.The timeouts to the program ranged from 87% to 4%. She did not read any words during the post-test.

Connie began Headsprout™ *Early Reading* at lesson one. She needed adult prompting until she was totally engaged in the program, at which point she would work independently. When beginning a lesson, she would exit out of Headsprout™ *Early Reading* in search of other preferred websites. Once engaged in the program, she would then progress independently and the adult prompts were faded. Connie was able to complete 5 lessons, 4 above 80% accuracy, one with 79%. She engaged in 13 sessions during ESY services. Her timeouts ranges from 50% (lesson 1) to 0% (lesson 5) (Table 2).

Table 2
Results for Students

	Amy	Josiah	Jack	Misty	Adelle	Connie
TOLD						
Standard Score	48	44	43	43	42	55
Pretest						
Total Words Read	93	0	0	0	0	0
Words Read Correctly	85	0	0	0	0	0
Post-test						
Total Words Read	153					
Words Read Correctly	147					
Total Lessons Completed	ER-23 RC-9	8	2	1	2	5
Lesson Scores 80% or above	ER-23 RC-4	3	2	1	2	4
Lesson Scores 70-79%		5				1
50-75% RC	RC-4					
Below 50% RC	RC-1					
Accessibility	VP, I	VP, I	VP	PP, VP	PP	VP, I

*Amy had difficulty with lessons 1-4 scoring between 50-75%. She also had difficulty with lesson 9 scoring below 50%
TOLD-Test of Language Development; ER-Early Reading Program; RC-Reading Comprehension; VP- Verbal Prompt, I-Independent; PP-Physical Prompt
*Amy's pretest scores placed her in lesson 57 of Headsprout™ Early Reading to begin the program. She quickly completed this program and moved to the next series, Headsprout™ Reading Comprehension.
The others started at lesson 1.

Discussion

This opportunity for investigation of computer-aided instruction (CAI) is needed because it is critical that school districts, service providers, and parents have information about the effectiveness of interventions before they invest in these computer-based products. The CAI Headsprout™ *Early Reading* and *Reading Comprehension* programs assisted the students involved in the intervention to identify words by clicking the mouse, and by beginning to learn much needed reading skills including the 5 core elements of reading (phonemic awareness, alphabetic principle, oral reading fluency, vocabulary, and comprehension). The researchers used CAI program data-based measures to provide progress data directly generated by the program to the home schools.

The teacher in this study reported that several students "enjoyed interacting with the computer instead of participating in small group instruction." The technology itself served to reinforce the reading learning process. She also stated that the students who were most successful could attend and interact with the program independently. This teacher worked with 5th and 6th grade students with ASD and DD in her home school self-contained classroom. She thought the autonomy of learning with Headsprout™ and the ability of the student to work at an individual pace was key. She also noted that each student would get the instruction needed without exposing reading limitations to peers. Headsprout™ gave teachers data driven progress results for students who's progress is typically difficult to measure.

It was noted that focus and attention (ability to independently attend to the program) impacted the ability to successfully navigate the program for 3 students. While a reduction in timeouts was noted for several students, whether the reduction in timeouts was due to increased attending or increased prompting from an adult, would need to be examined further. Three students were able to ultimately engage in the program independently, freeing the teacher and adults to work with other students while still able to collect data on student learning for those using the program.

While computer aided-instruction might not be appropriate for all students with ASD and DD and progress may vary, the progress shown by these six students in four weeks is of note. With continued use and familiarity with the program, it is possible that independent reading skills could emerge for them. The ability for the teacher to assess this progress without adult interface (which can be distracting in itself for students with autism) makes it a viable supplement to the reading curriculum. If the outcome sought is to develop independent reading and comprehension skills, both for academic and liesure, the positive outcome of CAI needs to be explored further and over longer periods of time. The fact that CAI gives teachers a way to measure reading comprehension progress for students who previously could not be readily measured is valuable as a data-driven intervention and valuable for all stakeholders providing services for students with ASD and DD.

The investigation of computer-aided instruction for students with ASD and DD expands the body of knowledge regarding interventions that work effectivel. By using the computer-based reading instruction, teachers will be able to determine progress in reading for students with ASD and

DD. Utilizing the Headsprout™ reading intervention continues the line of research regarding reading and technology-based interventions and will add to the research that determines "best practices" and emerging treatments for students with autism and developmental disabilities (National Autism Center, 2009).

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