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FOCUS ON EXCEPTIONAL CHILDREN

Literacy, Assistive Technology, and Students with Significant Disabilities

Karen A. Erickson, Penelope Hatch, and Sally Clendon

Literacy is a national educational priority. During the last decade, unprecedented funds have been committed to ensuring that school children, particularly those at risk for literacy-learning difficulties, have access to research-based instruction that is most likely to support their development as readers and writers. Yet, for the thousands of students across the country with significant intellectual disabilities, literacy instruction is a distant goal, and information regarding research-based instruction is extremely limited. Adding to the challenge is the absence of information regarding the use of assistive technology to support access to the curriculum *and* learning for students with significant intellectual disabilities. In this article, we review the research and apply understandings and strategies used in literacy instruction for students without disabilities to students with significant intellectual disabilities.

Students with Significant Intellectual Disabilities

This article specifically addresses students with significant disabilities including intellectual disabilities. In the United States, approximately 1% of school-aged students have intellectual disabilities (U.S. Department of Education, 2002). These are "characterized by significant limitations both in intellectual functioning and adaptive behavior as expressed in conceptual, social, and practical adaptive skills" and that originate before the age of 18 (American Association of Intellectual and Developmental Disabilities [AAIDD], 2009, para. 2). The term *mental retardation* has been used historically to describe this set of disabilities; however, the current preferred term is *intellectual disability* (AAIDD, 2009). The term *intellectual disabilities* has several synonyms, including *cognitive disability* (Centers for Disease Control, 2005), *intellectual impairment* (State of Queensland Department of Education, 2006), *cognitive impairment* (Beukelman & Mirenda, 2005), and *developmental disability* (U.S. Department of Health and Human Services, 2008). In this article, we use the term *intellectual disabilities* to represent all of these.

Dr. Erickson is the Director of the Center for Literacy & Disability Studies and a professor at the University of North Carolina at Chapel Hill. Dr. Hatch is a research associate at the Center for Literacy & Disability Studies at the University of North Carolina at Chapel Hill. Dr. Clendon is a senior lecturer in the Speech Language Therapy Programme at Massey University, Auckland, New Zealand.

Varying degrees of intellectual disability influence learning and the acquisition of adaptive skills differentially. The ways in which various degrees of intellectual disability are defined have changed over time. The *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-IV-TR*; American Psychiatric Association, 2000) relies on IQ scores to determine the severity of an individual's intellectual disabilities. Specifically, these levels are:

- mild or educable, as indicated by an IQ level of 50–55 to approximately 70;
- moderate or trainable, as indicated by an IQ level of 35–40 to 50–55;
- severe, as indicated by an IQ level of 20–25 to 35–40; and
- profound, as indicated by an IQ level below 20 or 25.

A more recent classification of the degree of intellectual disability focused on the level of support an individual requires rather than the person's IQ level (Luckasson, Borthwick-Duffy, & Buntix, 2002). The range of support includes intermittent, limited, extensive, and pervasive. The current article focuses specifically on the 15%–20% of students diagnosed with intellectual disabilities who require extensive or pervasive levels of support or fall into the moderate to severe and profound categories, and it is grounded in the belief that all students can make progress as readers and writers regardless of their level of intellectual functioning.

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Literacy

Literacy is used narrowly in this article to refer specifically to *reading* and *writing* (i.e., the cognitive processes of comprehending and composing meaning in written texts). This narrow definition is used in lieu of broader definitions that define idiosyncratic, nonconventional, and often symbol-based behaviors of students with significant intellectual disabilities as literate behaviors (Downing, 2005). Certainly, these behaviors are valuable as students develop their abilities to communicate meaningfully with others and participate in print-based activities, but these idiosyncratic, nonconventional, and symbol-based behaviors are emergent literacy behaviors at best. The danger in describing them as literate behaviors is that students with significant intellectual disabilities might be denied meaningful, intensive, ongoing opportunities to further develop their reading and writing skills and understandings because the skills and behaviors they are already demonstrating will be viewed as sufficient. As Koppenhaver (2000) stated:

> Unfortunately, our field has often treated emergent literacy as an end goal rather than a starting place. That is, practitioners have been quicker to accept emergent literacy and nonconventional performance than to consider how to move the student on to conventional reading and writing. (p. 273)

Reading and Writing Focus

The narrow focus on literacy as reading and writing is not intended to exclude students, as Downing (2005) warned. Rather, it is intended to ensure that the focus remains on research-based practices that build knowledge, skills, and abilities with the potential to result in reading and writing skills. Current laws mandate that all students be provided with access to the general curriculum. It is no longer acceptable to offer educational programs to students with significant intellectual disabilities that focus solely on developing other life or functional skills. In this article, we also take the position that it should be unacceptable to provide access to content without developing knowledge, skills, and understandings that will promote lifelong learning.

In the general education setting, literacy is an integral part of the curriculum. Beyond the obvious reading and writing demands in the areas of English and language arts, other core curriculum areas, such as science, social studies, and math, also present numerous literacy challenges. Without the ability to read and write, students can learn skills and information across the curriculum but cannot learn important lifelong skills that allow them to independently revisit and build on that information in the future.

Emergent Literacy

Literacy is narrowly defined as reading and writing in this article, but information is also provided to help students move toward this conventional use of reading and writing by supporting their emergent literacy learning. Emergent literacy is best defined as the reading and writing behaviors that precede and develop into conventional reading and writing (Teale & Sulzby, 1986). The vast majority of students with significant intellectual disabilities are currently emerging in their understandings and use of print. They are working to understand the functions of print and print conventions, phonological awareness, alphabet knowledge, and important receptive and expressive language skills such as vocabulary, syntax, and narrative skills.

Assistive Technology and Literacy Learning

Assistive technology (AT), as defined by the Individuals with Disabilities Education Act (2004), consists of "any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities." The law also defines AT services as "any service that directly assists a child with a disability in the selection, acquisition, or use of an assistive technology device." Appropriate and ongoing provision of AT services combined with carefully selected AT devices can minimize the numerous challenges faced by students with significant intellectual disabilities as they attempt to hold books, see standard print, use a pencil or standard keyboard, and employ numerous other skills required for reading and writing.

Despite its use for more than two decades, AT as a support for students with disabilities is not well understood (Matvy, 2000), and minimal empirical evidence is available to support AT in educational settings (Edyburn, 2003). The existing research has produced mixed results and has led to declarations of the "urgent need" to produce relevant and useful research about AT (Edyburn, 2005, p. 60). Students with significant intellectual disabilities, however, cannot wait for research on AT to support their engagement in meaningful literacy learning and use. Without immediate access to AT, most students with significant intellectual disabilities will fail to access information and successfully engage as learners.

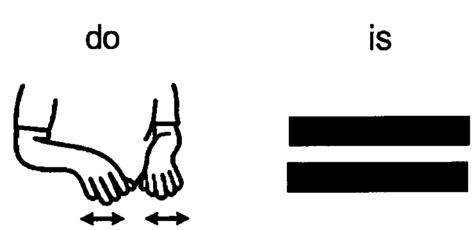
Through their work on Universal Design for Learning, Rose and Meyer (2002) were the first to make the distinction between AT to support access to information and AT to support access to learning. The purpose of the distinction was to help educators understand that maximizing access sometimes undermines learning. For example, if the educational goal for a student is to learn to decode words, providing the student with access to screen-reading software and digitized text will make it more difficult, not easier, for the student to reach the goal.

Many students with significant intellectual disabilities have co-occurring sensory or physical disabilities or both, which adds meaning to the distinction between access to information and access to learning. Assistive technology can be used to circumvent the challenges imposed by sensory and physical disabilities; however, as stated by Boone and Higgins (2007), "Mere access to the content is inadequate as an AT unless that access is mediated by instructional design supports appropriate for the specific disability of the user" (p. 138). Nowhere is this more important than in the education of students with significant intellectual disabilities who require intensive instructional supports.

Picture-Supported Text: An Example

The use of picture-supported text is one AT approach that is used widely with students who have significant intellectual disabilities. It provides a specific example of an approach with the potential to provide access to content while impeding access to learning reading skills. Picture-supported text involves pairing or replacing text with picture symbols (Downing, 2005). Software programs such as Boardmaker v.6 (Mayer-Johnson, 2006), PixWriter v.3 (Slater Software, 2008), and Writing with Symbols 2000 v.2.6 (Widgit Software, 2002) allow the user to type in or import running text and automatically or easily produce a picture symbol paired with each word. Although this practice is intended to provide access to text that a student could not read otherwise, it potentially makes it more difficult for the student to develop reading and writing skills (Pufpaff, Blischak, & Lloyd, 2000; Rose & Furr, 1984; Saunder & Solman, 1984).

For multiple reasons, pairing picture symbols with words may limit access to learning to read. Pictures actually may increase confusion, especially when they represent abstract concepts, have multiple meanings, or serve more than one grammatical function (Hatch, 2009). This is particularly true when words do not have obvious picture referents, as is the case with verbs such as *do* and *is*. Because they do not have picture referents, they must be represented by abstract, arbitrary symbols (see Figure 1). While the orthographic (print) representation of these words is also abstract, printed words appear much more frequently and are understood more



Source: From *Boardmaker* (Version 6) software (Pittsburgh: Mayer-Johnson, 2006).

FIGURE 1
Boardmaker Picture Communication Symbols for the Verbs *Do* and *Is*

broadly than are abstract picture symbols. As a result, students learning to read the words rather than recognize the abstract picture symbols have more opportunities to encounter the words and interact with others who understand them.

Picture symbols may also make learning to read more challenging when they represent multi-meaning words such as *back* and *play.* Each of these words has a consistent spelling across its multiple meanings, and neither spelling conjures a visual image that is related more closely to one meaning than another. In contrast, picture symbols representing these words offer visual representations of a single meaning. Consider the word *back*, which has a single spelling for its noun, verb, and adjective interpretations. The reader must use the words that surround it to know for certain which form is being used. In contrast, picture symbols might represent just the noun form of this word by illustrating a person's *back*, the *back* of a room, book, or building, or the athlete who is in the *back* position on the field.

These are just a few of the options for representing only the noun form of this word, and each choice communicates a clear meaning that may or may not match the intended use in a given context. Although today's software offers the option to select specific symbols for each use, words such as *back* and *play* would require students to learn literally dozens of symbolic representations with varying abstractness.

Beyond the potential confusion introduced when pictures are paired with words, pairing pictures with words seems to make it more difficult for students to learn to read the words. More than four decades ago, researchers began investigating the impact of pictures on the development of word identification for readers with and without disabilities of all ages. In the earliest of these studies (Samuels, 1967), first graders were more successful during training when pictures were paired with words, but the advantage of pictures disappeared when the students were asked to read the words without the pictures. With pictures, these students seemed to be learning more successfully during instruction, but in the end, they found it easier to read the words they learned without the benefit of pictures. In a follow-up study, other first graders receiving reading instruction that included pictures paired with words learned more slowly than did their peers who did not have pictures.

In a subsequent study (Singer, Samuels, & Spiroff, 1973–1974), more than 160 first- and second-grade students were randomly assigned to one of four intervention groups: picture + word; no picture + word; picture + sentence; and no picture + sentence. All of the students engaged in trials until they could identify the words without pictures present. The students had more correct responses during the training and learned words in fewer trials in the word-only conditions (no picture + word, no picture + sentence) than they did in the conditions that included pictures. These findings were replicated later for kindergarten nonreaders without disabilities (Blischak & McDaniel, 1995).

Research involving children and adults with intellectual disabilities has supported the findings of these studies involving typical primary-grade students. For example, Singh and Solman (1990) investigated the impact of pictures paired with words on the word reading skills of eight students with intellectual disabilities. All of the students read the fewest number of words correctly when they learned those words when paired with pictures. Similarly, the adults with intellectual disabilities studied by Pufpaff et al. (2000) learned to read printed words more easily than they learned to read words paired with pictures or words printed in enhanced ways with the picture embedded in the printed word.

A study by Fossett and Mirenda (2006) provided some guidance on how pictures should be used in reading instruction for students with intellectual disabilities. The authors used pictures to teach two students with intellectual disabilities to read individual words. In one method, the students were taught to read the words when they were paired directly with the pictures, and the second method required students to match the pictures to the printed words. The students were more successful when they actively matched pictures to printed words than they were when the words were paired with the picture.

Implications

Given the evidence suggesting that pairing pictures with words makes it more difficult to learn to read the words, educators must be clear regarding their goal when they choose to use technology to produce picture-supported text. If the goal is merely to provide access to content and careful attention is paid to selecting picture symbols that reflect the meaning of the words in the text, it is reasonable to expect that pictures will increase access to content that otherwise would not be accessible. If the goal is to improve reading skills, however, pairing pictures with text is likely to slow the rate at which students develop those skills. The research provides clear evidence that pictures should not be paired with words that students are expected to learn to read or spell. In either case, AT decisions require that we consider both access to content and access to learning if we want to ensure that students achieve their goals.

Emergent Literacy

Emergent literacy is composed of nonconventional—often idiosyncratic—behaviors and understandings that beginning readers and writers exhibit prior to achieving conventional literacy (see, e.g., Teale & Sulzby, 1986). Emergent literacy is a function of experience rather than development and, therefore, is not linked to a specific age level or level of cognitive or linguistic skill. Young children necessarily are emerging in literacy understandings because they have not had the experience required to be conventional readers and writers. Also, the literacy understandings of older children, adolescents, and adults might be emerging because they have not had adequate literacy learning experience.

Emergent literacy, reading, and writing exist along a continuum. Students with emerging understandings of literacy can be taught conventional literacy skills in isolation. The research literature is full of studies demonstrating that individuals with significant intellectual disabilities who have emerging understandings of literacy can learn to identify sight words in isolation (see Browder & Xin, 1998) long before they have developed basic concepts about print, alphabet knowledge, oral language understandings, or phonological awareness.

The problem with this approach is that development of these other basic concepts, skills, and understandings is required for word-identification skills to be used meaningfully in reading with comprehension (Dickinson, McCabe, Anastasopoulos, Peisner-Feinberg, & Poe, 2003; Nation & Snowling, 2004; Storch & Whitehurst, 2002). When sight words are taught in isolation without careful attention to development of these other concepts, skills, and understandings, emerging readers and writers struggle to use their word-reading skills to support their attempts to read, write, or communicate with others.

Successful progress as an emergent reader and writer requires that students be active and involved learners who apply their own "primitive hypotheses" (Clay, 2005, p. 9) when given opportunities to explore and interact with print (Sénéchal, LeFevre, Smith-Chant, & Colton, 2001). Emergent literacy understandings cannot be developed by completing tasks independently or learning skills in isolation. Instead, students must be actively involved in constructing their understandings of print, language, and the connections between the two by interacting with more literate others across multiple contexts and for multiple purposes.

The National Early Literacy Panel (NELP)

In the spring of 2009, the National Institute for Literacy (NIFL) published the *Report of the National Early Literacy Panel.* The National Early Literacy Panel (NELP) conducted a synthesis of the research regarding emerging literacy skills in children from birth through age 5. The NELP reports on five areas of intervention: code-focused interventions, shared reading, parent and home programs, preschool and kindergarten programs, and language enhancement. The NELP concluded that interventions across the five areas had a moderate to large effect on emergent literacy learning and that each influenced later conventional reading and writing development for the young children without disabilities who were included in the research they reviewed.

Although the NELP did not include research regarding students with disabilities in its review, the NELP findings can guide decisions regarding appropriate emergent literacy interventions for students with significant intellectual disabilities. For example, the NELP found that code-related interventions focusing on building phonological awareness and alphabetic knowledge (letter names and sounds) have a direct, positive impact upon the later development of conventional reading and writing skills. Similarly, shared book experiences that promote interactions and engagement have a direct, positive impact on later conventional literacy skills.

In contrast, the NELP provides no evidence to suggest that we should teach students who are emerging in their understandings of reading and writing to identify sight words. Although it is commonly recommended that functional sight word reading be integrated into the day-to-day instructional program of students with significant intellectual disabilities who are emerging in their literacy understandings (see e.g., Browder & Spooner, 2006), these sight-word identification skills have no relationship with later conventional word reading skills (Ehri, 2005). Thus, the time and energy spent teaching functional sight words do not contribute to future conventional reading and writing abilities and could be better spent on language and other skills that will contribute to later success.

Research addressing the areas identified by the NELP involving students with significant intellectual disabilities is limited; however, the research that does exist provides important information regarding the nature of the emergent literacy intervention that we should provide. Three studies addressing emergent literacy development for students with significant intellectual disabilities are described here. Two of the studies reported on classroom interventions and the third reported on a parent intervention. In all cases, the interventions reflect at least some of the findings of the NELP (NIFL, 2009).

MEville to WEville Programs

MEville to WEville: Early Literacy and Communication Curriculum (AbleNet, 2004). The first classroom study (Erickson, Clendon, Abraham, Roy, Van de Carr, 2005) investigated the impact of this curriculum on the early literacy development of 23 children with significant intellectual disabilities. The teachers were supported to use AT to assist the children as they engaged in emergent literacy activities such as book sharing, code-focused interventions, and other lessons to support vocabulary and language learning. After 8 weeks of intervention, the children demonstrated moderate gains in print knowledge (Cohen's $d = .51$).

MEville to WEville (AbleNet, 2004). This program is an early literacy and communication program designed specifically to address the needs of students with significant intellectual disabilities. It does so by offering teachers an integrated set of lessons that provide students with the opportunity to be active and involved learners who apply their own "primitive hypotheses" (Clay, 2005, p. 9) when given opportunities to explore and interact with print (Senechal, LeFerve, Smith-Chant, & Colton, 2001). It is important that *MEville to WEville* supports teachers in integrating AT throughout instruction to provide access to information while supporting learning.

This program reflects the findings of the NELP (NIFL, 2009) by including shared reading, code-related interventions, parent and home connections, and language learning lessons. It is the only commercially available program that addresses each of these areas while supporting teachers in integrating appropriate AT into each lesson. Whether teachers use the actual program or look to it as a model to organize their own emergent literacy intervention program, the *MEville to WEville* (AbleNet, 2004) program provides an important approach to building the emergent literacy understandings that are most likely to promote later conventional reading and writing success.

Other Classroom Interventions

In another classroom intervention, Koppenhaver and Erickson (2003) evaluated the impact of emergent literacy interventions for preschool-aged children with a diagnosis of autism and significant intellectual disabilities. The interventions involved dramatically increasing access to reading, writing, and print-related activities while also increasing the level of interactions with adults in the classroom during the activities. Assistive technology was used in a number of ways to support the children in their efforts to interact with books (e.g., adapted traditional books, books on the computer), engage in writing (e.g., letter stamps, alternate keyboards, standard computers with talking word processors), and develop their alphabet knowledge and phonemic awareness (e.g., voice output communication devices, computer software).

As children used this wide range of AT, they interacted with researchers and classroom staff. They received no explicit instruction in literacy skills, but the adults were intentional in their efforts to develop the children's emergent literacy understandings while interacting with print. In 4 months, the children had gained understanding in concepts of print, alphabet knowledge, and writing skills, suggesting that the approach was successful in helping these children with significant intellectual disabilities.

As described by Koppenhaver and Erickson (2003), the intervention involved several features that reflect the finding of the NELP (NIFL, 2009). For example, students were provided with AT to support them in commenting, labeling, and otherwise interacting actively while engaged in shared reading with adults. Students were provided with access to letters and sounds through various toys, games, and AT that allowed them to explore and receive feedback regarding letters, sounds, and phonological awareness.

Parent and Home Programs

At least one study demonstrates that parent programs can be as effective for students with significant disabilities as they are for the typically developing children in the research reviewed by the NELP (NIFL, 2009). Skotko, Koppenhaver, and Erickson (2004) taught mothers of girls with Rett syndrome to use simple AT, including augmentative communication strategies to improve the quality of book-sharing interactions with their daughters. For example, the mothers were taught to relate events in the book to their child's experience and ask more prediction and inference questions, even though their children had limited means of communication and could not respond precisely.

Mothers also were taught to respond to their child's attempts by attributing meaning and to encourage efforts to use the simple augmentative communication devices by prompting the communication act rather than the physical act of hitting the switch. Finally, the mothers were taught to dramatically increase the wait time they provided so their children could respond more successfully to their questions or initiate comments of their own. The intervention led to improved communication for the girls. The parent book-sharing intervention in this study led to some of the same types of gains that resulted in the large effect size for parent-directed book-sharing interventions analyzed by the NELP (NIFL, 2009).

Summary

These studies provide a convergence of evidence suggesting that students with significant intellectual disabilities who are emerging in their understandings of print benefit from many of the same types of interventions that yield strong effects on language and literacy outcomes for children without disabilities. Importantly, these interventions focus both on the areas of intervention identified by the NELP (NIFL, 2009) and also on the instructional or pedagogical approaches. The students with significant intellectual disabilities in these studies were not relegated to rote learning of isolated skills related to these important areas of intervention but were provided with intensive opportunities to engage meaningfully with print across multiple contexts and with a variety of more literate others. These findings are important because they highlight areas of the general curriculum in reading and literacy that, when accessed, albeit often at different chronological ages, lead to positive outcomes for students with significant intellectual disabilities.

Using Assistive Technology to Support Emergent Literacy Learning

In the above studies, several simple technologies played an important role in the success of the interventions. For example, single-message voice output devices were used by the teachers in the *MEville to WEville* study and by the mothers in the book-sharing interactions with their daughters. In both cases, the single-message devices were programmed with messages that supported open-ended commenting and initiation (e.g., "I know about that," "Tell me more," "What do you think?") rather than specific responses. When students are emerging in their understanding of literacy, we must support them in maximizing the number their successful interactions with more literate others during literacy activities. One means to ensure this is to program these single-message devices with open-ended responses.

Other voice output devices also play an important role during emergent literacy learning. Sequenced message devices allow students with significant intellectual disabilities and complex communication needs to engage in multi-turn interactions that help them learn about the give-and-take of communication. A sequenced message device allows the student to hit the same button repeatedly to produce a series of messages in a predetermined sequence. These sequenced messages can focus on communication acts such as providing multiple-step directions, reporting on the events of a day, or telling a story from beginning to end.

In addition to communication technologies, students who have emerging understandings of print need access to tools they can use to support their early attempts at writing. Students who are physically able can use standard computers or computers with alternative keyboards and talking word processors to explore letters, sounds, and the way they are combined to make words. Students with physical disabilities who cannot access these standard tools can use their eyes to point to letters in a display or listen to a partner verbally scan through the letters of the alphabet while pointing to each letter on a printed display. The student could use a single message voice output device to indicate WRITE THAT FOR ME or two single message devices to direct the adult to GO TO THE NEXT ONE or WRITE THAT FOR ME.

Whatever the means, students with significant intellectual disabilities who are emerging in their understandings of literacy must have ample opportunities to engage in the same type of explorations of writing that typically developing children receive as they play with crayons, chalk, markers, pencils, and pens. More information about these approaches to accessing the alphabet for writing in emergent literacy is available at the Center for Literacy and Disability Studies (CLDS) website, in the section on writing with alternative pencils (http://www.med.unc.edu/ahs/clds/).

By the time typically developing children reach kindergarten, most have had more than 1,000 hours of meaningful experiences with print (Heath, 1983). A great deal of this time is spent interacting with books both independently and through shared reading with their caregivers. For many reasons, students with significant intellectual disabilities have had far more limited opportunities to engage meaningfully with print.

One reason is that many students with significant intellectual disabilities have difficulty interacting with books or sustaining their attention on books when looking at them independently. To address this issue, a team at the University of North Carolina at Chapel Hill, led by Karen Erickson and Gary Bishop, created Tar Heel Reader (http://tarheelreader.org) Originally intended to address the needs of adolescents and young adults with significant intellectual disabilities who were emergent or early conventional readers, Tar Heel Reader now has thousands of beginning-level books for emergent and beginning readers of all ages. Written by educators and others across the globe, the content of Tar Heel Reader is driven by users' needs.

The Favorites feature allows educators to set up collections of books for students to access and browse, read, and/or listen to independently. With this collection of free books, students with intellectual disabilities should have more success in approaching the thousands of hours of interactions with print that typically developing children experience before we expect the former to begin to engage in conventional reading and writing instruction.

Conventional Literacy

For decades, the research in conventional literacy for students with significant intellectual disabilities has concentrated almost exclusively on approaches to sight word instruction (Browder & Xin, 1998). Although this emphasis has changed slightly over the last decade, there continues to be a need for more research directed specifically to students with significant intellectual disabilities and that investigates more of the areas involved in literacy (e.g., comprehension, fluency, phonics). Until we start to provide students with significant intellectual disabilities access to the comprehensive conventional literacy instruction that their peers receive, we will not see dramatic changes in the number of these students who are conventional readers and writers.

A Comprehensive Approach to Literacy Instruction

Students without disabilities who are learning to read in the primary grades have access each day to comprehensive instruction that addresses the multiple components of successful reading. The National Reading Panel (NRP; NICHD, 2000) defined these components as phonemic awareness, phonics, vocabulary, fluency, and text comprehension. At the very least, students must have access to instruction each day that supports their ability to read words (phonemic awareness, phonics, and word identification) and read text with comprehension (fluency, vocabulary, and text comprehension) combined with instruction aimed at improving their ability to write text to communicate with others.

In this article, this combination of instructional components is called *comprehensive instruction.* Unfortunately, students with significant intellectual disabilities rarely have access to comprehensive instruction that addresses each of these things (Katims, 2000). When they do receive conventional literacy instruction, it tends to involve mastery of lists of sight words (Browder, Courtade-Little, Wakeman, & Rickelman, 2006) or skills taught in isolation. Research, however, clearly demonstrates that students with significant intellectual disabilities can make progress in conventional literacy when they have access to comprehensive instruction (Erickson, Koppenhaver, Yoder, & Nance, 1997; Hedrick, Katins, & Carr, 1997; Hogan & Wolf, 2002; Ryndak, Morrison, & Sommerstein, 1999; Wershing & Hughes, 2002).

The lack of attention to comprehensive instruction for students with significant intellectual disabilities is likely attributable to a number of factors. For example, functional word reading is widely viewed as a critical component of education for students with significant intellectual disabilities (Browder & Spooner, 2006), whereas developing the skills to read text with comprehension is not. Also, the prevailing belief is that individuals with developmental disabilities, particularly those with intellectual disabilities, cannot learn to decode words using phonics-based strategies and, therefore, must focus on sight word reading (Kaderavek & Rabidoux, 2004).

Further, descriptions of methods used to provide students with intellectual disabilities with access to the general curriculum in reading and literacy recommend explicitly teaching sight word skills while "exposing" students to other components of the literacy curriculum (Browder et al., 2006) or selecting only those areas of the curriculum that are most meaningful to the child (Downing, 2005). Whatever the reason, research and practice regarding other areas of comprehensive reading instruction for students with significant intellectual disabilities is sparse. We will describe issues and instruction related to word reading and comprehension, along with assistive technologies that can support children in these areas.

Reading Words

Word identification is the component of reading that involves translating printed words into pronunciations aloud or subvocally (Cunningham, 1993; Cunningham, Koppenhaver, Erickson, & Spadorcia, 2004). As one component of successful reading, word identification can occur in two main ways: through *decoding,* or using letter–sound knowledge to construct a pronunciation, or through *word recognition,* which requires readers to use their familiarity with the spelling of a word to match the printed word with a pronunciation stored in memory (Cunningham et al., 2004). Readers often access the meaning of words while reading them, but good readers are able to identify words that have an unknown meaning or no meaning at all (pseudowords). The ability to identify words and the ability to understand their meanings are two separate processes that each must be addressed through instruction.

Beginning word readers identify words by remembering selected visual features of the word (Gough, Juel, & Griffith, 1992). This word reading is the earliest form of word reading and can occur in the absence of letter–sound knowledge (Ehri, 2005). The *Edmark Reading Program* (Riverdeep, 1992) is an example of a reading instructional program available in print and software versions that is often used with students with significant intellectual disabilities. The program teaches students to attend to the visual features rather than the letter–sound associations within the word. Like other sight word instructional programs, the *Edmark Reading Program* teaches word reading using what Ehri (2005) calls a prealphabetic approach that does not contribute to word reading during more advanced stages of reading.

Although most readers begin reading words using the prealphabetic approaches employed in programs such as the *Edmark Reading Program,* programs that apply research-based approaches developed for students without disabilities immediately focus on the individual letters and letter combinations in words and the sounds associated with them. In this way, beginning readers quickly transition to using their knowledge of letter–sound relationships to construct a pronunciation and then store those pronunciations in memory (Ehri, 1998). Unfortunately, students with significant intellectual disabilities are rarely provided with the opportunity to learn to apply letter–sound knowledge in reading words. A growing body of research, however, suggests that they can learn these skills when they are provided with sequential, systematic instruction (Hanser & Erickson, 2007).

In their review of successful approaches to word reading instruction, the NRP (NICHD, 2000) found that, to read successfully, students needed to develop skills that would allow them to decode words. Two approaches they identified are: *synthetic* (which emphasizes letter–sound relationships) and *large-unit* (which emphasizes spelling patterns within words) approaches. Neither of these approaches was determined to be superior to the other (NICHD, 2000), but each has characteristics that make it more or less accessible to students with significant intellectual disabilities. Understanding these two approaches to decoding (phonics) instruction is necessary to understanding the existing research and its application to students with significant intellectual disabilities.

Synthetic approaches. Synthetic approaches to decoding or phonics are the most widely recognized approaches. A synthetic phonics approach emphasizes individual graphemes (individual letters or letter combinations) and phonemes (the sounds those letters and letter combinations make). In synthetic approaches, the grapheme–phoneme relationships are taught individually, and then students are taught to synthesize or blend the sounds to pronounce the word. Typically, lessons present reading words that share common graphemes and phonemes, followed by opportunities to read words, sentences, and simple passages that were written specifically to provide practice with the new skills. Most programs that employ a synthetic approach require students to achieve mastery with one set of letters and sounds before introducing new letters and sounds.

Two difficulties with synthetic approaches were highlighted by the NRP (NICHD, 2000) and have been raised with regard to students with intellectual disabilities in particular (Flores, Shippen, Alberto, & Crowe, 2004). First, blending letter sounds to create a pronunciation for a word requires the deletion of extra sounds that are made when saying the name of some consonants separately. For example, when saying the sound for the letter *p* in isolation, an additional vowel is added, and the result is pronounced /puh/. To segment a word that begins with *p*, such as *pat*, the letters pronounced in isolation typically sound like /puh/ /a/ /tuh/. To blend these sounds together to say the complete word, the extra vowel sounds must be deleted.

The second challenge with a synthetic approach is the demand it places on working memory. Blending three sounds is not particularly challenging, but blending five or six sounds places significant demands on memory, because students have to remember and manage the order of the sounds.

Typically, synthetic approaches begin with learning a set of letter sounds and the skills to blend those letter sounds in simple words and nonwords. A critical component of this instruction is the need for students to produce the sounds so teachers can evaluate and correct their efforts. Many students with significant intellectual disabilities have complex communication needs that make it difficult, if not impossible, for them to articulate individual letter sounds and blend them together. With these students, alternatives must be considered. Based on the difficulty that one participant's speech presented as he attempted to sound out letters and words, Flores et al. (2004) suggested that speech and language abilities be considered carefully before selecting a synthetic phonics program.

Synthetic approaches and students with significant intellectual disabilities. Two studies investigated the effectiveness of synthetic phonics approaches developed specifically to accommodate students with intellectual disabilities and complex communication needs (Fallon, Light, McNaughton, Drager, & Hammer, 2004; Light, McNaughton, Weyer, & Karg, 2008). Fallon et al. (2004) investigated the effects of a direct instruction approach on the single word reading skills of students with intellectual disabilities and complex communication needs. They designed a word reading intervention using 5 short vowel sounds and 9 consonants, which were combined to create a corpus of 75 consonant–vowel and consonant–vowel–consonant words. A picture was then selected to represent each of the 75 words so students could point to an array of pictures or match words to pictures to demonstrate their word reading skills. Five students (ages 9–14) were recruited for participation. All but one had moderate levels of intellectual disabilities, and all had complex communication needs. The students worked individually with a researcher who taught them to match single sounds to the initial sounds of words, to blend sounds into words, and to read simple consonant–vowel and consonant–vowel–consonant words.

During instruction emphasizing these word reading skills, student errors were corrected using a model–prompt–check procedure. The total number of 30-minute sessions required by participants ranged from 10 to 34. All of the participants reached criterion on the trained words, but only one reached criterion on untaught words. The lack of generalization to novel words may reflect the lack of sound blending skills, but the students reached criterion because the multiple presentations of the words during the sessions allowed them to map the spelling of the printed word to its internal pronunciation or picture-based meaning without applying letter–sound knowledge.

In a second study, Light et al. (2008) used similar approaches to teach letter–sound correspondences, decoding, and sight word recognition to students with intellectual disabilities and complex communication needs. Word reading was just one component of the intervention, which also included instruction in phonological awareness and letter–sound correspondences before moving on to word reading instruction, reading connected text, reading comprehension, and early writing. Over the course of 16 months of instruction (55 hours total), one 8-year-old girl learned 20 letter–sound relationships and 60 words; however, the same challenges with interpretation exist. In learning to read the words through the sounding-out strategy, the girl had repeated exposure to the printed word with its pronunciation and a picture referent. Growth in word decoding cannot be confirmed without more evidence of generalization to untaught words.

Large-unit approaches. Large-unit approaches to word reading emphasize the analysis and blending of larger parts or chunks of words such as onsets (all the letters preceding the first vowel in a syllable), rimes (all of the letters from the first vowel through the end of the syllable), and spelling patterns. Usually, large-unit approaches include instruction in decoding by analogy, through which students learn to use parts of known words to decode unfamiliar words. One benefit of large-unit approaches is that those larger units can have more meaning (because they are morphemes) and can be linked to key words that serve as points of reference for the student and the teacher (Gaskins, Downer, & the Teachers of Benchmark School, 1986; Gaskins et al., 1988). Recent research involving large-unit approaches with struggling readers suggests that beginning readers make the most progress when large-unit approaches are combined with approaches that emphasize letter–sound relationships such as synthetic approaches (Ehri, Satlow, & Gaskins, 2009).

Large unit approaches and students with significant intellectual disabilities. Joseph and McCachran (2003) investigated the use of word sorts, a form of large-unit word reading instruction, with students with mild-to-moderate intellectual disabilities. Intervention was provided each day for 20 minutes for 8 weeks (more than 13 hours total). All words used in the word-sort lessons had CVC or CVCC spelling patterns. During each lesson, students had 3 category words and a deck of 12 words to sort according to sound and spelling patterns in the category words. After attempting the sort, the children read the words and were encouraged to self-correct.

The results suggested that the students benefited from the instruction in terms of gains in letter and word identification, but the results were inconsistent across participants. The authors suggested that word sorts may not be effective for all students with intellectual disabilities. Current research, however, would suggest that word sorts would work best in combination with approaches emphasizing letter–sound relationships such as synthetic approaches (Ehri et al., 2009).

Combining synthetic and large-unit approaches. Hanser (2008) investigated the effectiveness of a combined approach to phonics instruction for students with complex communication needs, including one student with moderate intellectual disabilities. Across 25 days of instruction, the participants engaged in 45–60 minutes of instruction employing a spelling-based approach to synthetic phonics with word sorts and other large-unit instructional strategies. The three participants all made gains in word identification and spelling words with clear evidence of generalization beyond the items that were taught. Although the duration of the intervention was insufficient to allow the participants to become conventional readers and writers, they did make measurable gains in ability to read and spell taught and untaught words.

Using assistive technology to support word reading. The intervention that Hanser (2008) used in her investigation of word reading instruction for students with intellectual disabilities and complex communication needs is one of a number of instructional programs published in the last 5 years that employ varying forms of AT to support word identification for students with significant intellectual disabilities. Programs such as *Literacy through Unity* (Erickson & Hanser, 2007) and *Tango to Literacy* (Donnelly & King-DeBaun, 2008) teach students with significant intellectual disabilities to identify words while teaching them to use sophisticated augmentative and alternative communication (AAC) devices. Both of these programs target the development of letter–sound strategies to read words while teaching strategies for using the vocabulary on the communication devices to support communication. One published study of the *Literacy through Unity* program suggested that it has the potential to improve literacy and communication skills for students with significant intellectual disabilities using *Unity* communication software on a Prentke-Romich AAC device (Hanser & Erickson, 2007).

Another new research-based program is the *Accessible Literacy Learning Curriculum* (Light & McNaughton, 2009), designed to address the needs of students with developmental disabilities who cannot use speech to communicate. Students are taught to blend, segment, and recognize letter–sound relationships so they can apply the skills in decoding words. The program utilizes a direct instruction approach to teach each of these skills to mastery in sequence with sight word reading (reading words by attending to visual cues rather than letter–sound relationships) instruction subsequent to mastery of a letter–sound-based approach to word reading.

In addition to these structured programs that were developed to teach word identification to students with significant intellectual disabilities, a number of technologies support students in learning about letters, sounds, and their relationships with words that were not designed specifically for this population or purpose. For example, Co:Writer® 6 (Don Johnston, 2009) is a word prediction program originally designed to reduce the number of keystrokes required to type a word. The most recent versions provide a much broader range of support. As students type a letter, Co:Writer® produces a list of words that begin with the sound represented by the letter (e.g., if the student types *c*, the Co:Writer® program will predict words that begin with *c* and *s*). Students then can read the words in the list or run the mouse over each word to hear the computer read it aloud. If the desired word is not present, the student can type more letters representing the sounds in the desired word, and Co:Writer® will revise its list of predicted words.

Some research evidence suggests that students with learning disabilities improve their reading, spelling, and writing skills as result of using Co:Writer® (MacArthur, 1998; Staples, Heying, & McLellan, 1995). In addition, anecdotal evidence is mounting that students with significant intellectual disabilities can learn letter sounds and apply that knowledge to read words when they have had access to Co:Writer® while learning to read sight words by discriminating visual features of the words (see e.g., McNulty, 2009).

Word Maker (Don Johnston, 2004) is a computer-based instructional program that was designed to support beginning and struggling readers in their learning to use letter-sound knowledge to read and spell words. Although the program was not designed with students with significant intellectual disabilities as the target, some students involved in projects with the Center for Literacy and Disability Studies are using it successfully in conjunction with teacher-directed instruction. Specifically, these students are completing a teacher-directed lesson from the book *Systematic Sequential Phonics They Use* (Cunningham, 2000), upon which the software was developed, and then they are independently completing the parallel lesson in *Word Maker* to practice applying the skills. This combination, though not the subject of research to date, is leading to improved reading and spelling for the students involved.

Reading Text with Comprehension

The purpose of reading is to comprehend meaning that is conveyed in print (Adams, 1990). Historically, reading comprehension has been overlooked in reading research because it was believed to be a byproduct of successful word recognition (Lipson & Wixson, 2009). Today, it is understood that successful reading comprehension involves concurrently extracting and constructing meaning from text via a process involving *interaction* of the reader, the text, and the activity (RAND Reading Study Group, 2002).

The *Simple View of Reading* (Gough & Tumner, 1986) offers an explanation of the manner in which these component skills interact in successful reading with comprehension. The *Simple View* holds that reading is a combination of decoding (linking printed words with their pronunciations) and linguistic comprehension (interpreting word level semantic information within a sentence or text). Obviously, reading a text with comprehension requires successfully reading the words; however, adequate word reading skills do not ensure successful reading with comprehension (Nation & Norbury, 2005). Students can possibly have the skills to read all of the words in a text without having the skills to understand them (Hoover & Gough, 1990; Nation & Norbury, 2005).

Research confirms a relationship between poor reading comprehension and weak receptive language skills (Nation, 2005; Snowling & Hulme, 2005). For example, in one study, students with Down syndrome and Williams syndrome who had weak receptive language skills demonstrated reading comprehension abilities commensurate with their receptive, oral language skills (Snowling & Hulme, 2005). Given that individuals with significant intellectual disabilities typically have concomitant language impairment, it is necessary to provide systematic comprehension instruction as part of their comprehensive literacy instruction.

Text comprehension. At least two different aspects of written language or text comprehension must be addressed through instruction. The first is knowledge of text structures and the assumptions that authors make about readers. The second is knowledge of the world and the receptive understandings of vocabulary and other oral language skills. Developing knowledge of text structures requires experience with a broad range of text types including both narrative and expository texts, as well as notes, letters, online text, poems, and all of the other forms of text that are commonly used. An intervention that uses only a single type of text will prevent students from developing the knowledge of text structures required to support comprehension.

In oral language, the ability to understand how language is used is called *pragmatics*. In written language, pragmatics is directly related to knowledge of text structures and the things that authors expect their readers to accomplish while reading. For example, most texts require students to make inferences to fill in gaps while reading, using a combination of information in the text and knowledge they bring to the reading event (Kintsch & Rawson, 2005). When they fail to make inferences or fill in gaps by drawing upon their own knowledge, poor reading results (Cain & Oakhill, 1999). As with oral language, however, development of this ability to make inferences while reading requires broad experience and informative feedback. Just as students can develop pragmatic skills in oral language, they can learn to make inferences while reading and generally learn how written language works.

Vocabulary. As defined by Neuman and Dwyer (2009),

> vocabulary refers to the words we must know to communicate effectively: words in speaking (expressive vocabulary) and words in listening (receptive vocabulary). Children use the words they hear to make sense of the words they will eventually see in print. Vocabulary instruction, therefore, must be more than merely identifying or labeling words. Rather, it should be about helping children to build word meanings and the ideas that these words represent. By understanding words and their connections to concepts and facts, children develop skills that will help in comprehending text. (p. 385)

Vocabulary seems to relate most to reading through its connection to receptive language comprehension. Beginning readers who can speak actually translate print to speech so they can take advantage of receptive language vocabularies, which are expected to be larger than beginning reading vocabularies (Kamil, 2004). To be successful in reading and understanding words, beginning readers must associate each printed word they encounter with a word that already exists in their oral language vocabularies. As they become more skilled, vocabulary is required for successful comprehension of connected text, and the size of one's vocabulary is directly related to reading ability (Stanovich, Cunningham, & Freeman, 1984).

To be successful in learning to read with comprehension, students need a large oral vocabulary even when their understandings of literacy are emerging (Neuman, 2006; NIFL, 2009). Students without significant disabilities can learn new word meanings in isolation, but they are more successful when they are engaged actively in learning new words (see Dole, Sloan, & Trathen, 1995), encounter those words repeatedly across multiple contexts, and participate in instruction that employs multiple methods (NICHD, 2000).

Approaches to Comprehension Instruction

Given the absence of information regarding comprehension instruction that specifically targets students with significant intellectual disabilities, successful approaches to teaching text comprehension must draw upon research-based approaches used with students who do not have disabilities. Further, the approaches that are employed must take into account that many students with significant intellectual disabilities have complex communication needs that make it difficult, if not impossible, for them to engage ongoing discussions while reading. At the CLDS, this has led to the use of a five-step comprehension lesson framework based on the work of Tierney and Cunningham (1984), which supports students in comprehending text. Five steps are used in a before, during, after instructional framework.

Step 1: Build or activate background knowledge.

The knowledge of the world that a reader brings to a text is critical to eventually understanding that text. This knowledge of the world, or background knowledge, sometimes can be called up from an existing knowledge base, but in other cases it must be taught. Students' background knowledge can be activated by asking them to (a) recall all of the words they can think of related to a topic; (b) categorize words that relate to the topic to be read; or (c) recall a specific event, activity, or experience that relates to the topic to be read.

Background knowledge can be built by (a) teaching students the meaning of important vocabulary, (b) demonstrating completion of the type of comprehension task (e.g., sequencing) by relating it to something familiar (e.g., sequence of the meals eaten every day or the days of the week), or (c) watching a video that is related to the topic.

Step 2: Set a purpose for reading.

After activating or building the requisite background knowledge, a purpose for reading must be identified *before* reading. Students do eventually have to learn how to set their own purposes when reading, but during instruction, purposes should be set prior to reading. Setting a clear purpose focuses the reader's attention and increases the likelihood of success. For students with significant intellectual disabilities, a clearly stated purpose helps them attend to the important aspects of the text and combine this with their background knowledge to support their understanding of the text.

Some example purposes that are accessible to students with intellectual, physical, and/or communication impairments are the following:

- Read this so you can sequence these events (written on sentence strips).
- Read this so you can select five words that describe the main character (or setting).
- Read this so you can identify the character in the story who is most like someone you know.

Step 3: Read or listen.

Actually reading the text or listening to someone else read the text should occupy the majority of instructional time. If the activities in steps 1, 2, 4, and 5 take longer than the reading itself, something is wrong. Time spent reading with meaning is the most important factor in supporting reading growth.

Step 4: Complete a meaningful and relevant task.

After reading, students should complete a task that relates directly to the purpose that was set before reading. If students were told to read in order to sequence, the task should require them to sequence. Nothing more! If other aspects of the text are important to understand, read it again for a different purpose.

Step 5: Provide informative feedback

The final step after reading is to work with students to understand what they did to accomplish the task. The goal is to help them understand exactly what they did to get the correct answer or to understand how they got an incorrect answer so their misunderstandings can be clarified. This step differs from correct feedback or reinforcement because it focuses on understanding *how* the student accomplished the task rather than on the final result of completing the task.

Certainly, other frameworks can support comprehension learning, but this before–during–after approach provides a structure to ensure that students have the support they need in building or activating their knowledge of the world. It also directs the reading process to maximize the likelihood that students with significant intellectual disabilities will be successful in learning to read with comprehension.

Using Assistive Technology to Support Reading with Comprehension

A variety of tools are available with the potential to support reading comprehension for students with significant intellectual disabilities. Some of the technologies are mainstream technologies such as YouTube and TeacherTube, which can be used to support the development of world knowledge relative to the text being read. Viewing brief videos that build relevant background knowledge prior to reading can provide a solution for students with significant intellectual disabilities who often lack life world knowledge as a result of limited experiences and language delays or disabilities.

Other technologies that can support comprehension include the numerous screen-reading tools that offer supports for vocabulary, note taking, and self-questioning or comprehension monitoring. These tools were designed originally to support readers and writers with visual impairments or learning disabilities, and they offer important supports to students with significant intellectual disabilities as well. For example, students who physically click on individual words within the text can get support in understanding the meaning of individual words. Students who are reading for a specific purpose can take notes by highlighting important information in the text. Students who struggle to remember their purpose for reading or have difficulty monitoring their own success in reading to achieve a predetermined purpose can be supported with these tools, using features that allow teachers to insert questions and prompts throughout the text.

Tar Heel Reader can be used to support students by allowing them to read easy texts on topics related to the more difficult texts they are struggling to understand. Further, teachers can use the easy texts on Tar Heel Reader to help students with significant intellectual disabilities learn how to think about text while reading text without the barriers imposed by high word–reading demands. After reading several texts on Tar Heel Reader related to more complex texts, students will have increased background knowledge and knowledge of text structures required to read other texts with comprehension.

Next Steps

The last decade has been witness to a dramatic increase in our collective knowledge of literacy, assistive technology, and significant disabilities, but we have a great deal more to learn. Currently, the vast majority of students with significant intellectual disabilities are emerging in their understandings of literacy. This may be a result of the nature of the challenges they face in learning, but the literature provides evidence that the language, cognitive, communication, physical, and sensory challenges these students face do not always prevent them from learning to read and write (Blischak, 1995; Erickson et al., 1997; Hanser & Erickson, 2007; Light et al., 2008).

During the past 5 years, several instructional programs addressing literacy for students with significant disabilities have appeared. Most have a modest research base to support their use, but each represents only a starting place. Using these new programs in combination with what we know about emergent and conventional literacy for students without disabilities increases the likelihood that these programs will lead to success in literacy learning. Until every student with significant intellectual disabilities is given access to the tools and supports they require to emerge in their understandings of print, we will not know what is possible.

This article provides a description of our current understandings of literacy for students with significant intellectual disabilities. It draws heavily on the "mainstream reading literature" that Saunders (2007) reminded us has had "little impact on the field of mental retardation [sic], despite recognition of this gap in the literature" (p. 79). As Saunders further stated, "There is a need for intensive teaching studies that incorporate the best of what is known about reading instruction in typically developing children" (p. 82).

Until completion of these studies that address both the literacy content of the general curriculum and the "best of what is known about" the methods for teaching that content, we must get started with what we do know. We must carefully select instructional methods and technologies and combine them in comprehensive approaches to literacy instruction. Whether students with significant intellectual disabilities are emerging in their literacy understandings or are among the few who are reading and writing conventionally, a comprehensive approach is most likely to address their individual areas of need while this intense need for research is being addressed.

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Research

The Impact of Aided Language Stimulation on Symbol Comprehension and Production in Children With Moderate Cognitive Disabilities

Michael D. Harris
University of Wisconsin–River Falls

Joe Reichle
University of Minnesota–Twin Cities

Over the past decade, aided language stimulation has emerged as a strategy to promote both symbol comprehension and symbol production among individuals who use graphic mode communication systems. During aided language stimulation, an interventionist points to a graphic symbol while simultaneously producing the corresponding spoken word during natural communicative exchanges. The purpose of this study was to determine the impact of aided language stimulation on children with moderate cognitive disabilities. Three preschool children with moderate cognitive disabilities who were functionally nonspeaking participated in the investigation. The investigator implemented a multiple-probe design across symbol sets/activities. Elicited probes were used to determine whether the children increased their comprehension and production of graphic symbols. Results indicated that all 3 children displayed increased symbol comprehension and production following the implementation of aided language stimulation.

Key Words: augmentative and alternative communication, augmented input, aided language stimulation, moderate cognitive disability

The majority of intervention strategies for persons requiring augmentative and alternative communication (AAC) have focused on elicited production. Several well-documented instructional strategies have been used to teach symbol production using direct instruction with individuals who have moderate-to-severe disabilities (Carr, Binkoff, Kologinsky, & Eddy, 1978; Carrier, 1974; Romski, Sevcik, & Pate, 1988; Sigafoos, Laurie, & Pennell, 1996). Others have used direct instruction strategies embedded within natural contexts (Reichle & Brown, 1986; Reichle & Sigafoos, 1991; Reichle & Yoder, 1985). Several investigators have reported the successful implementation of milieu teaching strategies, which might be useful for AAC users as well (Halle, 1982; Halle, Marshall, & Spradlin, 1979; Hart & Risley, 1975; Warren, McQuarter, & Rogers-Warren, 1984).

Each of these intervention strategies has focused on the feedback and reinforcement from the communicative partner as a primary mechanism accounting for the success of the procedure. However, research emerging during the past decade has suggested that speaking children learn to comprehend and produce words that are frequently spoken to them (Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991). More recent naturalistic intervention approaches have capitalized on this knowledge and incorporated language input strategies into teaching new words (Girolametto, Weitzman, & Clements-Baartman, 1998; Tannock & Girolametto, 1992). It is quite possible that similar processes contribute to learning to comprehend and produce graphic symbols. In AAC, spoken language input may well contribute to learning the meaning associated with a graphic symbol. Spoken language input might come from a voice output communication aid (VOCA) and/or from a communicative partner (Goossens', Crain, & Elder, 1992; Schlosser, Belfiore, Nigam, Blischak, & Hetzroni, 1995). Two AAC intervention approaches, the System for Augmenting Language (SAL; Romski & Sevcik, 1992, 1996) and aided language stimulation (Elder & Goossens', 1994; Goossens', 1989; Goossens' et al., 1992), advocate augmented input as part of a comprehensive intervention package to establish augmentative communication competence.

Romski and Sevcik (1996) described the implementation of the SAL during a 2-year longitudinal study with 13 male youths with moderate or severe mental retardation.

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The authors described four basic components of the SAL that included (a) a VOCA, (b) symbols and the lexicon, (c) teaching through natural communicative exchanges, and (d) the communicative partner's use of the VOCA. The teaching method consisted of loosely structured natural communicative experiences that were embedded into the participants' regularly occurring routines. The investigators taught communicative partners to use the VOCA as a supplement to their own spoken communication as a form of augmented input. Although all participants acquired symbols, a post-hoc analysis of participant performance revealed two achievement patterns. Four participants displayed what the authors termed a beginning achievement pattern. Beginning achievers were slow in acquiring symbols and learned fewer than 20 symbols during the 2-year period. The other 9 participants displayed an advanced achievement pattern. Advanced achievers rapidly acquired at least 35 symbols during the 2-year period.

Goossens' et al. (1992) described aided language stimulation as pointing to "key symbols on the learner's communication display in conjunction with all ongoing verbal language stimulation being directed toward that [learner]" (p. 11). Aided language stimulation has been implemented with and without the use of VOCAs (Elder & Goossens', 1994; Goossens' et al., 1992). Goossens' (1989) reported on the implementation of aided language stimulation with a 6-year-old, functionally nonspeaking female with severe spastic-athetoid cerebral palsy who was learning English as a second language. Before intervention, the child spoke 5 Korean words and 10 English word approximations. Her developmental level was estimated to be at least 16–20 months. During a 7-month period, interventionists implemented a multicomponent experientially based augmentative communication stimulation program that included concurrently implemented selection techniques, direct selection eye gaze, and switch access. During intervention, the interventionist pointed to key graphic symbols on the child's communication display in conjunction with ongoing spoken language stimulation. In addition to clinician-delivered intervention, the learner's parents were provided with hands-on training. Results indicated the emergence of both graphic symbol communication and functional speech.

Schlosser et al. (1995) compared VOCA and non-VOCA augmented input conditions while teaching lexigrams to 3 individuals with severe to profound mental retardation. In the VOCA condition, the experimenter told the participant to "point to _________" and immediately modeled the correct symbol-selecting response. During this condition, the participant received augmented input in the form of synthetic speech. During the non-VOCA condition, the experimenter told the participant to "point to _________" and immediately modeled the correct response but did not actually touch the key on the VOCA (consequently, no synthesized message was produced). The investigators reported that the 3 participants reached criterion during the VOCA condition. Two participants also reached criterion during the non-VOCA condition. However, implementing augmented input resulted in fewer teaching sessions to reach criterion.

Although recent studies have supported the use of augmented input (Goossens', 1989; Romski & Sevcik, 1996; Schlosser et al., 1995), several authors have indicated the need for further empirical support for aided language stimulation (Beukelman & Mirenda, 1998; Sevcik & Romski, 2002). Sevcik and Romski indicated that "evaluating augmented input or aided language stimulation as an AAC intervention is sorely needed" (p. 470). The purpose of this study involving children with moderate cognitive disability was twofold: (a) to determine whether aided language stimulation (non-VOCA) increased symbol comprehension, and (b) to determine whether aided language stimulation (non-VOCA) increased symbol production (object labeling).

Method

Three preschool children participated in aided language stimulation activities with each of 12 new object vocabulary items. Experimenters scrutinized the effect of aided language stimulation on participants' symbol comprehension and symbol production through a series of probes completed during baseline, intervention, and maintenance phases of the study.

Participants

Three preschool children with moderate cognitive disabilities who were functionally nonspeaking (spoken vocabulary of no more than 30 words) participated. None of the children's individualized education plans contained objectives for learning graphic or gestural symbols.

The children met the following inclusionary criteria: (a) moderate cognitive disability as determined by a licensed school psychologist, (b) an expressive vocabulary of less than 30 words as determined by administration of the MacArthur Communicative Development Inventories (Fenson et al., 1993), (c) the ability to directly select pictures and objects using a finger or thumb, (d) normal vision as determined through examination of school records, and (e) normal hearing as determined through examination of school records.

During an identity matching assessment, 10 black and white Picture Communication Symbols (Mayer-Johnson, 1992) were used with each child. The experimenter randomized the position of the symbol choices and the presentation of symbol samples across opportunities. The experimenter placed an array of four symbol choices centered approximately 8–10 in. in front of the child. He held up a symbol sample and said, "Find this." The experimenter recorded the child's first selection of a symbol choice. No corrective feedback was offered. Each symbol was probed twice.

The experimenter implemented a fast-mapping task adapted from Mervis and Bertrand (1994) with each child. Four sets of objects were used. Each set contained five objects: four common objects for which the child already comprehended the names and one object for which the child was not expected to know the name. Examples of known objects included book, ball, and shoe. Examples of unknown objects included garlic press and turkey baster (a novel, one-syllable nonsense label was assigned to the unknown object). Four exposure opportunities were followed by comprehension opportunities. During the exposure opportunities, the experimenter arranged the five objects in a row and encouraged the child to manipulate them. The experimenter asked the child for one of the known objects (e.g., "May I have the ball?") and for the unknown object (e.g., "May I have the lep?"). If the child responded incorrectly to the nonsense label or did not respond at all, the experimenter showed the child the correct object and allowed the child to manipulate the object. During this time, the experimenter labeled the object three times. During opportunities in which the child responded correctly, he or she was allowed to play with the object while the experimenter labeled it three times. This input was provided to reinforce the child's correct mapping as per the Mervis and Bertrand protocol. After the exposure opportunities were completed for two sets of objects, the comprehension opportunities were implemented for those two sets. During these opportunities, the experimenter placed the same five objects, along with an unknown distractor, in front of the child. Again, the child was asked for either a known object or the original unknown object. The order of requesting the known and unknown objects was counterbalanced. Following comprehension opportunities for the first two sets of objects, the procedure was repeated for the remaining two sets of objects. Percentage correct was calculated based on comprehension opportunities for unknown objects separately.

Jennie.

Jennie, age 3;10 (years;months), was a Caucasian female with Down syndrome. She was enrolled in an early childhood special education classroom. Her composite score on the Vineland Adaptive Behavior Scales (Sparrow, Balla, & Cicchetti, 1984) was 55. A licensed school psychologist administered this instrument and indicated that the scores were consistent with a diagnosis of moderate cognitive disability. Her age equivalent on the Peabody Picture Vocabulary Test (Dunn & Dunn, 1997) was less than 1;9. The MacArthur Communicative Development Inventories (Fenson et al., 1993) indicated that Jennie comprehended 143 words and produced 3 spoken words. Jennie scored 100% on the identity matching task. She met criterion with 75% correct on the fast-mapping task.

Niles.

Niles, age 5;4, was a Caucasian male with Down syndrome. He was enrolled in an early childhood special education classroom. A licensed school psychologist evaluated Niles' cognition. He scored 3 standard deviations below the mean on the cognition section of the Mullen Scales of Early Learning (Mullen, 1985). This score was consistent with a diagnosis of moderate cognitive disability. His composite score on the Vineland Adaptive Behavior Scales (Sparrow et al., 1984) was 61. Niles' age equivalent on the Peabody Picture Vocabulary Test (Dunn & Dunn, 1997) was less than 1;9. The MacArthur Communicative Development Inventories (Fenson et al., 1993) indicated that Niles comprehended 87 words and produced 11 spoken words. Niles scored 100% on the identity matching task. He met criterion with 75% correct on the fast-mapping task.

Edie.

Edie, age 4;2, was a Caucasian female with no specified diagnosis. She was enrolled in an early childhood special education classroom. A licensed school psychologist implemented several standardized assessments with Edie. Edie's composite score on the Bayley Scales of Infant Development (Bayley, 1993) was more than 3 standard deviations below the mean. She scored below the first percentile on the Mental Development Index (Bayley, 1993). Edie's performance on these assessments was consistent with a diagnosis of moderate cognitive disability. Her age equivalent on the Peabody Picture Vocabulary Test (Dunn & Dunn, 1997) was less than 1;9. The MacArthur Communicative Development Inventories (Fenson et al., 1993) indicated that Edie comprehended 121 words and produced 14 spoken words. Edie scored 100% on the identity matching task. She scored 100% on the fast-mapping task.

Materials

Individual symbols used during elicited probes consisted of laminated 3 × 3 in. black and white Picture Communication Symbols (Mayer-Johnson, 1992). The symbol arrays consisted of 3 × 3 in. black and white Picture Communication Symbols that were affixed to 10 × 7 in. laminated cards. The experimenter arranged the symbols in two rows, with three symbols in the top row and three symbols in the bottom row. The symbols were spaced .125 in. apart from one another. The communication boards used during scripted routines consisted of 3 × 3 in. black and white Picture Communication Symbols affixed to a laminated $8^1/_2 \times 8^1/_2$ in. card. Symbols were arranged in two rows, with two symbols in the top row and two symbols in the bottom row. Symbols were positioned .125 in. apart. The objects used during elicited probes and scripted routines included life-sized plastic fruit, metal miniature vehicles, wooden miniature furniture, an 18-in. tall plastic doll (body parts), and actual cloth cleaning items (see Table 1).

Participant Preassessment and Stimuli Development.

Preassessment probes were conducted to develop a pool of 12 objects and 12 corresponding graphic symbols that the children did not comprehend or produce. Comprehension probes required the children to match a line-drawn symbol choice to an object sample named by the experimenter. Production probes required the children to match an object sample to a line-drawn symbol choice (Brady, 2001).

Four opportunities per stimulus were presented in comprehension probes and four opportunities per stimulus were presented in production probes. If the child comprehended or produced a symbol with 0% or 25% accuracy, that symbol and its corresponding object were used during the baseline, intervention, and maintenance phases of the study. Table 1 lists the symbol and object sets that were identified for each child.

Line-Drawn Symbol to Object Matching (Comprehension). During comprehension probes, the experimenter placed an array of six objects, approximately 2 in. apart, in

TABLE 1. Object and symbol sets for Jennie, Niles, and Edie.

Participant	Set Number	Target Stimuli	Distractors
Jennie	1	Plastic apple Plastic peach Plastic pear Plastic tomato	Plastic orange Plastic pepper
	2	Toy bench Toy cupboard Toy desk Toy stove	Toy dresser Toy washer
	3	Doll back Doll chin Doll knee Doll shoulder	Doll elbow Doll wrist
Niles	1	Toy bolt Toy chisel Toy drill Toy wrench	Toy pliers Toy screwdriver
	2	Toy tractor Toy trailer Toy truck Toy van	Toy car Toy train
	3	Plastic apple Plastic peach Plastic pear Plastic tomato	Plastic orange Plastic pepper
Edie	1	Toy bolt Toy chisel Toy drill Toy level	Toy screwdriver Toy tape measure
	2	Plastic apple Plastic plum Plastic strawberry Plastic tomato	Plastic orange Plastic pepper
	3	Dishcloth Scouring pad Sponge Washcloth	Dish towel Hot pad

front of the child. The experimenter randomized the position of the six object choices and the individual presentation of symbols across opportunities. During each opportunity, the experimenter said, “Show me the _______” while simultaneously pointing to the line-drawn symbol representing an object. The child’s first response was recorded during four probes per object that were implemented each session. The experimenter provided no corrective feedback.

Object to Line-Drawn Symbol Matching (Production). During production probes, the experimenter placed an array of six symbols in front of the child. The position of the six symbol choices and the presentation of objects were randomized across opportunities. Holding an object in his hand, the experimenter asked, “What is this?” He recorded the child’s first response. The experimenter conducted four probes per symbol during each session.

Setting

Sessions took place in Jennie’s school during the academic year and summer session. During school vacation, sessions took place in her home. Sessions for Niles’ academic year and summer session occurred at school. During school vacations, sessions took place in his day care. Edie’s sessions took place at her educational day care setting.

Independent Variable

Aided language stimulation was the independent variable. Aided language stimulation was defined as the experimenter pointing with his finger to a referent in the environment and sequentially pointing (within 2 s of the original point) to a graphic symbol while saying the name of the referent. The experimenter implemented the independent variable during scripted routines. In the short excerpt that follows, the words written in upper case represent examples of when the experimenter implemented aided language stimulation during a scripted routine:

> Niles, let’s put the TRUCK in the garage. Nice job, you put the TRUCK in the garage. Now let’s put the VAN in the garage. That’s a noisy VAN.

Experimental Design

The experimenter implemented a single-subject, multiple-probe design (Horner & Baer, 1978) across symbol sets/activities. Following baseline measures for all three symbol sets associated with each of three activities, two activities (and their associated symbol sets) remained on baseline while intervention began during the first activity (and its associated symbol set). For Jennie and Niles, a criterion of 75% accuracy across five consecutive sessions for symbol comprehension performance was established to trigger the onset of intervention in the next object/symbol sets. To be consistent with other educational objective criteria being implemented in Edie’s school setting, her classroom teacher requested that Edie’s performance be set at 75% accuracy across three consecutive sessions for symbol comprehension.

Procedures

The study was implemented in three phases: (a) baseline, (b) intervention, and (c) maintenance. Across phases, stimuli were centered a standard 8–10 in. in front of each child. The experimenter probed each target symbol or each target object twice during each session. Noncontingent praise for participation was provided throughout all phases of the investigation.

Baseline.

Scripted Routine. The interventionist interacted with the participant during a scripted routine designed for a preferred activity. The participants’ classroom teachers identified preferred activities. Before beginning the scripted routine, the experimenter placed a communication board in front of the child. The experimenter randomized the position of the symbols for each session. The experimenter did not implement the independent variable during baseline (i.e., although the communication display was in view, it was not used during the baseline phase). Target objects were referred to using personal and demonstrative pronouns (i.e., it, this, that) during the scripted routine. The experimenter referred to each object four times during each baseline session.

Comprehension of Graphic and Spoken Symbols. All stimuli were chosen during the preassessment phase of the study. Twelve objects (four different objects for each of three activities) and 12 graphic symbols (four symbols corresponding to the objects used in the same three activities) were probed during baseline. The experimenter placed an array of six objects in front of the child. Four objects served as target objects, and two objects served as distractors. Distractors were objects that belonged to the same stimulus class as the target objects (e.g., fruit, furniture, body parts, vehicles, cleaning items), but were not a focus of intervention. Distractor objects were unknown to the children. Table 1 provides a list of target objects and distractors. During each opportunity, the experimenter said, "Show me the _______" while simultaneously pointing to the line-drawn symbol representing an object. The experimenter probed each target object twice during each session and recorded the number of correct responses. No corrective feedback was provided. A correct response was scored if, within 10 s, the child independently pointed to (or manipulated) the object corresponding to the experimenter's spoken word and line-drawn symbol presentation. The percentage of objects correctly identified was calculated for each probe by dividing the number of correct responses by the total number of opportunities and multiplying by 100. The position of the object choices and the presentation of symbol samples were randomized across opportunities. Daily probes were implemented for symbol comprehension before each baseline scripted activity session.

Production of Graphic Symbols. The experimenter placed an array of six symbol choices in front of the child. Four symbols served as target symbol choices, and two symbols served as distractors. Distractors were symbols that belonged to the same stimulus class as the target symbols, but were not a focus of intervention. The experimenter randomized the position of the symbol choices and the presentation of object choices across opportunities. Holding an object sample in his hand, the experimenter asked, "What is this?" The experimenter probed each target symbol twice during each session and recorded the number of correct responses. No corrective feedback was provided. A response was scored as correct if, within 10 s, the child independently pointed to the symbol corresponding to the object presentation and query (i.e., "What is this?"). The percentage of symbols correctly identified was calculated for each probe by dividing the number of correct responses by the total number of opportunities and multiplying by 100. Daily probes were implemented for symbol production before the baseline scripted routine on the days they were conducted.

Comprehension of Exclusively Graphic Symbols. The procedures used to measure comprehension of exclusively graphic symbols were identical to those used to measure comprehension of graphic and spoken symbols; except when the objects were in place, the experimenter said "Show me" as he pointed to the line-drawn symbol representing the object. The experimenter did not present the spoken object name.

Comprehension of Exclusively Spoken Symbols. The procedures used to measure comprehension of exclusively spoken symbols were also identical to those used to measure comprehension of graphic and spoken symbols; except when the objects were in place, the experimenter said, "Show me the (spoken object name)." The experimenter did not present the line-drawn symbol representing the object.

Intervention.

Scripted Routine. The experimenter used aided language stimulation during a scripted routine designed for a preferred activity. Before beginning the scripted routine, the experimenter placed a communication board in front of the child. If the child was not directing his or her gaze toward the communication board, the experimenter placed the communication board approximately 12 in. in front of the child's face before pointing to each target graphic symbol on the communication display. The experimenter referred to each object/symbol four times during each session. The position of the symbols displayed was randomized before each session.

Comprehension of Graphic and Spoken Symbols. The experimenter conducted daily probes for symbol comprehension before each daily scripted routine. Nontarget symbol sets that remained in baseline phase (while the experimenter implemented intervention for the target symbol set) were probed every two to four sessions. The experimenter conducted probes during intervention according to the protocol described for the baseline phase.

Production of Graphic Symbols. These probes were implemented every 2 to 4 days throughout the intervention phase. The procedures were described in the baseline phase.

Comprehension of Exclusively Graphic Symbol. When criterion was met for comprehension of graphic and spoken stimuli, these probes were implemented to determine whether a child could respond to exclusively graphic symbols. The experimenter began these probes before the next daily session following criterion performance for the comprehension of graphic and spoken stimuli.

Comprehension of Exclusively Spoken Symbols. When criterion was met for comprehension of graphic and spoken stimuli, the experimenter implemented these probes to determine whether the child could respond to exclusively spoken symbols. The experimenter began these probes before the next daily intervention session.

Maintenance.

All maintenance probes were implemented using procedures identical to those that were used during baseline and intervention.

Comprehension of Graphic and Spoken Symbols. The experimenter conducted maintenance probes for Jennie 8, 16, 25, 58, and 91 days postacquisition criteria for Symbol Set 1; 24, 40, and 47 days postacquisition criteria for Symbol Set 2; and 13, 20, and 27 days postacquisition criteria for Symbol Set 3. He conducted maintenance probes for Niles 14, 21, and 28 days postacquisition criteria for Symbol Set 1; 21, 35, and 46 days postacquisition criteria for Symbol Set 2; and 9, 20, and 42 days postacquisition criteria for Symbol Set 3. The experimenter conducted maintenance probes for Edie 13, 25, and 33 days post-acquisition criteria for Symbol Set 1; 8, 15, and 34 days postacquisition criteria for Symbol Set 2; and 11, 19, and 45 days postacquisition criteria for Symbol Set 3.

Production of Graphic Symbols. Probes were conducted on the same day as maintenance probes for comprehension of graphic and spoken symbols.

Interobserver Agreement

A graduate student in speech-language pathology served as an independent observer. The observer had extensive experience with children having cognitive disabilities. Before the study, the experimenter trained the observer to identify procedural steps, recognize child responses, and use data sheets. The observer independently recorded child responses and treatment integrity during 35% of all sessions for Jennie, 34% of all sessions for Niles, and 36% of all sessions for Edie. An agreement was scored when the experimenter and the observer both scored the same response. Interobserver agreement was calculated by dividing agreements by agreements plus disagreements and multiplying by 100 (Schlosser, 2002). Interobserver agreement for dependent measures was 100% for Niles and for Edie, and ranged from 87.5% to 100% (M = 99.44) for Jennie.

Interobserver agreement for treatment integrity was 100% for Niles and for Edie, and ranged from 83% to 100% (M = 99.63) for Jennie. Reliability was based on correct implementation of the following procedural steps for elicited probes: (a) appropriate setup of materials, (b) appropriate use of discriminative stimuli during elicited probes (e.g., graphic symbol, spoken symbol, graphic and spoken symbol), (c) randomization of symbols/objects between sessions, (d) probing in random order, and (e) no cueing or corrective feedback. Reliability was based on correct implementation of the following procedural steps for scripted routines: (a) appropriate setup of materials, (b) placing the communication board within child's view, (c) pointing to the referent in the environment before pointing to the symbol, (d) verbalizing the conventional spoken symbol while simultaneously pointing to the graphic symbol, and (e) sampling each symbol/object four times.

Results

For each child, following the establishment of a stable baseline, a gradual increase in symbol comprehension and symbol production was observed for Symbol Set 1 during the intervention phase of the study (see Figures 1, 2, and 3). The number of instructional opportunities required to meet the preestablished acquisition criterion decreased considerably for 2 of the children after the introduction of the second symbol set. Niles showed a 54% decrease in instructional opportunities required to reach criterion for Symbol Set 2, and Edie showed a 75% decrease in instructional opportunities required to reach criterion for Symbol Set 2. The number of teaching opportunities required to reach criterion for Symbol Set 3 was nearly identical to that required for Symbol Set 2 for Niles and for Edie. Although Jennie only showed a 10% decrease in instructional opportunities required to reach criterion for Symbol Set 2, she displayed a 50% decrease in instructional opportunities required to reach criterion for Symbol Set 3 (compared to Symbol Set 2).

The rate of acquisition for symbol comprehension and symbol production differed for each participant. Jennie displayed a faster rate of acquisition for symbol comprehension than she did for symbol production for two of the three symbol sets. Rate of acquisition for symbol comprehension and symbol production was relatively equal for the remaining symbol set. Niles displayed equal rates of acquisition for symbol comprehension and symbol production on two of the three symbol sets. On the remaining symbol set, he showed a faster rate of acquisition for symbol production. When he reached criterion on this symbol set, he was consistently 75% accurate on symbol comprehension probes and 100% accurate on symbol production probes. Edie displayed equal rates of acquisition for symbol comprehension and symbol production for Symbol Sets 1 and 2. She showed a faster rate of acquisition for symbol comprehension for Symbol Set 3. Post-intervention probes indicated performance maintained at criterion level for all 3 children, with the exception of Jennie's first two maintenance probes for symbol comprehension on Symbol Set 1.

Jennie responded to exclusively graphic stimuli and exclusively spoken stimuli with equal performance on Symbol Set 1 (see Figure 4). She responded with nearly equal performance on Symbol Sets 2 and 3, with only a small bias toward attending to exclusively graphic stimuli. Niles responded to exclusively graphic stimuli and exclusively spoken stimuli with nearly equal performance on Symbol Set 2, but showed a slight propensity to respond to exclusively graphic stimuli on Symbol Sets 1 and 3 (see Figure 5.) Edie responded to exclusively graphic and exclusively spoken stimuli with equal performance on Symbol Set 1, while showing a tendency to respond to exclusively graphic symbols on the remaining two Symbol Sets (see Figure 6).

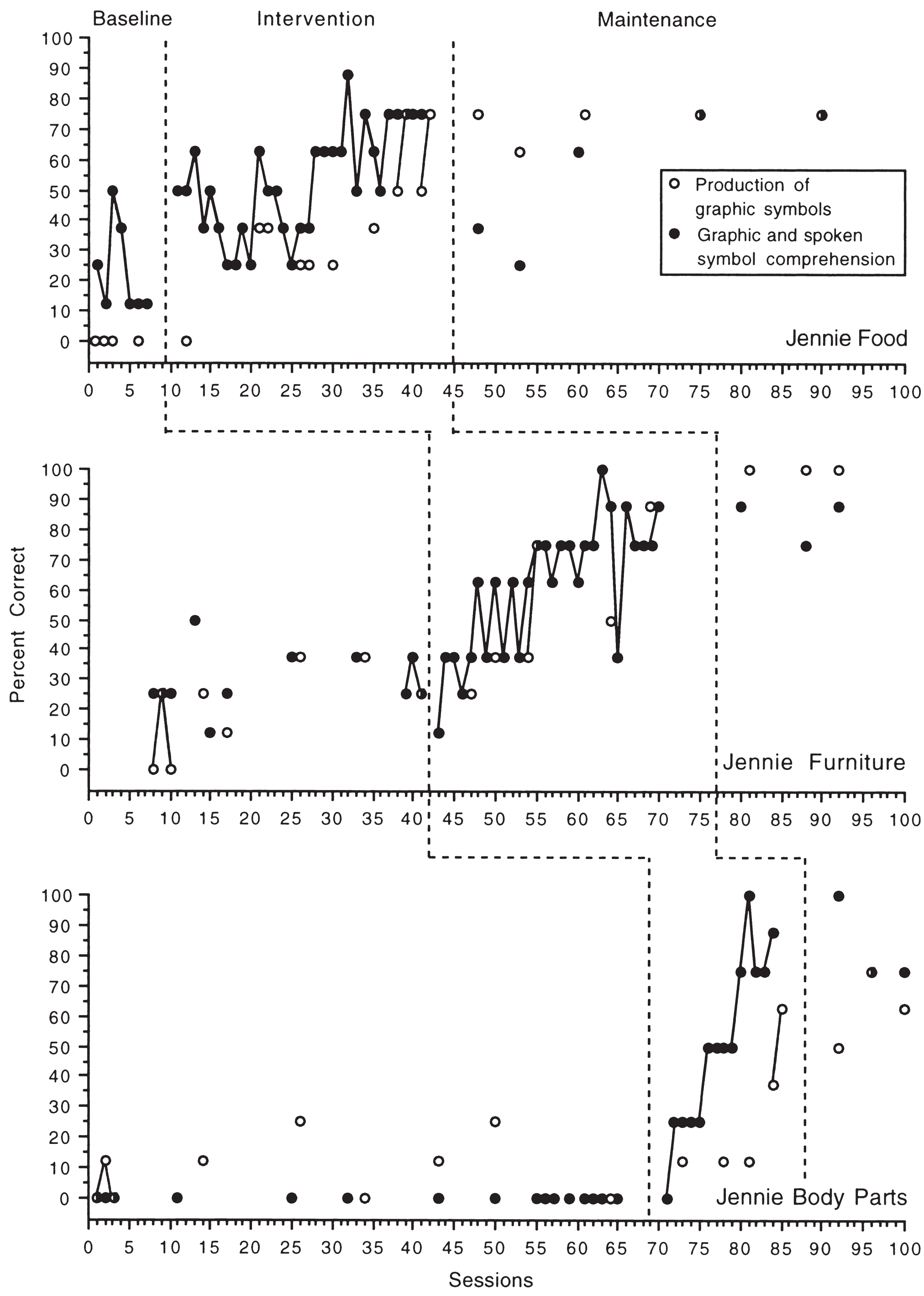
Discussion

The results of this investigation support the hypothesis that aided language stimulation facilitates symbol comprehension in individuals with moderate cognitive disability who are functionally nonspeaking. The findings also support the hypothesis that aided language stimulation facilitates symbol production (object labeling). Additionally, the findings indicate that symbol comprehension and symbol production were maintained.

During aided language stimulation, the experimenter simultaneously exposed the children to both graphic and spoken stimuli. The results shown in Figures 4–6 indicate that participants attended to both the visual and the auditory aspects of the compound stimulus.

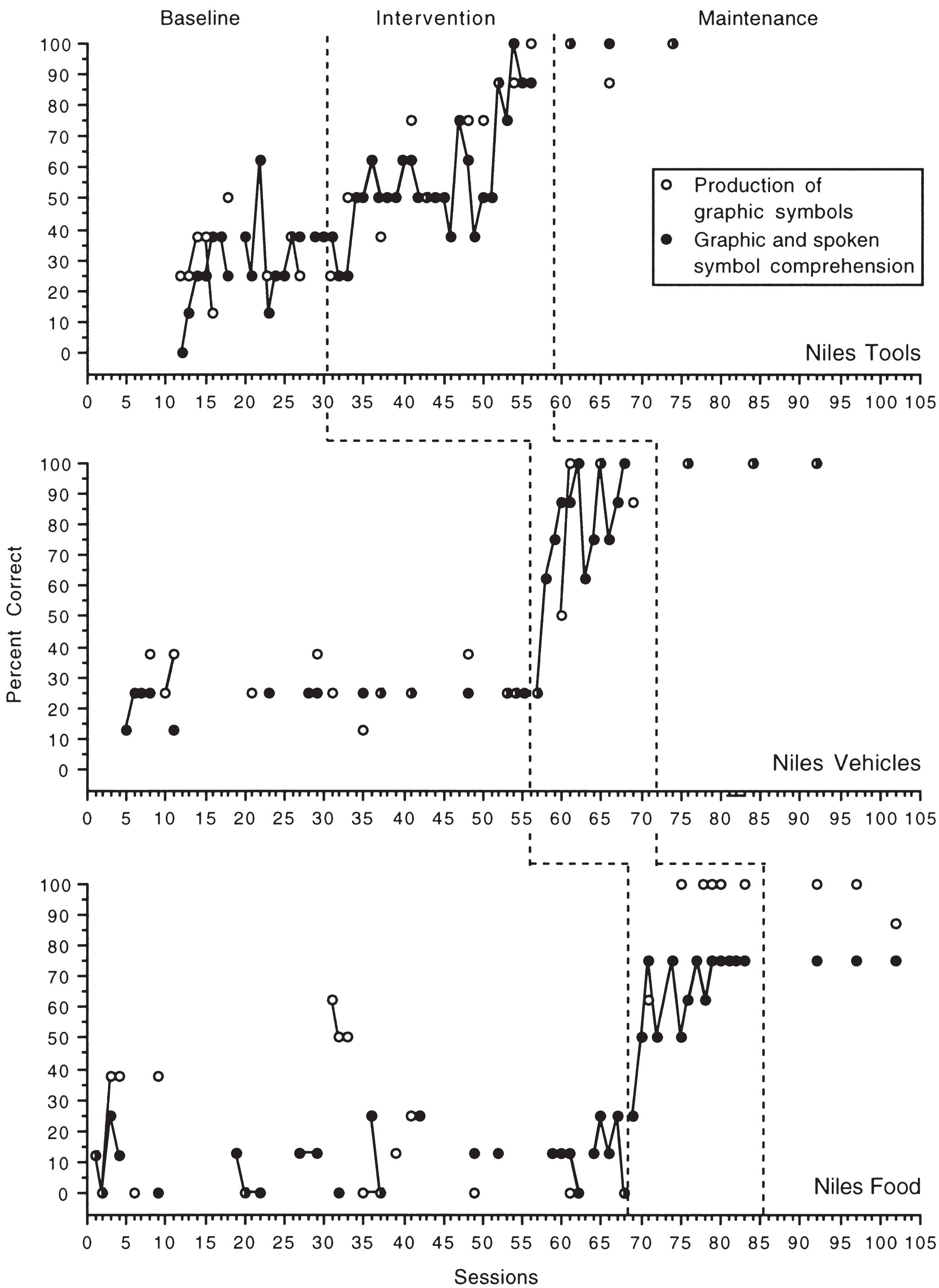
The relationship between comprehension and production is complicated in AAC (Brady, 2001). In the current

FIGURE 1. Percent correct for symbol comprehension and production for Jennie.



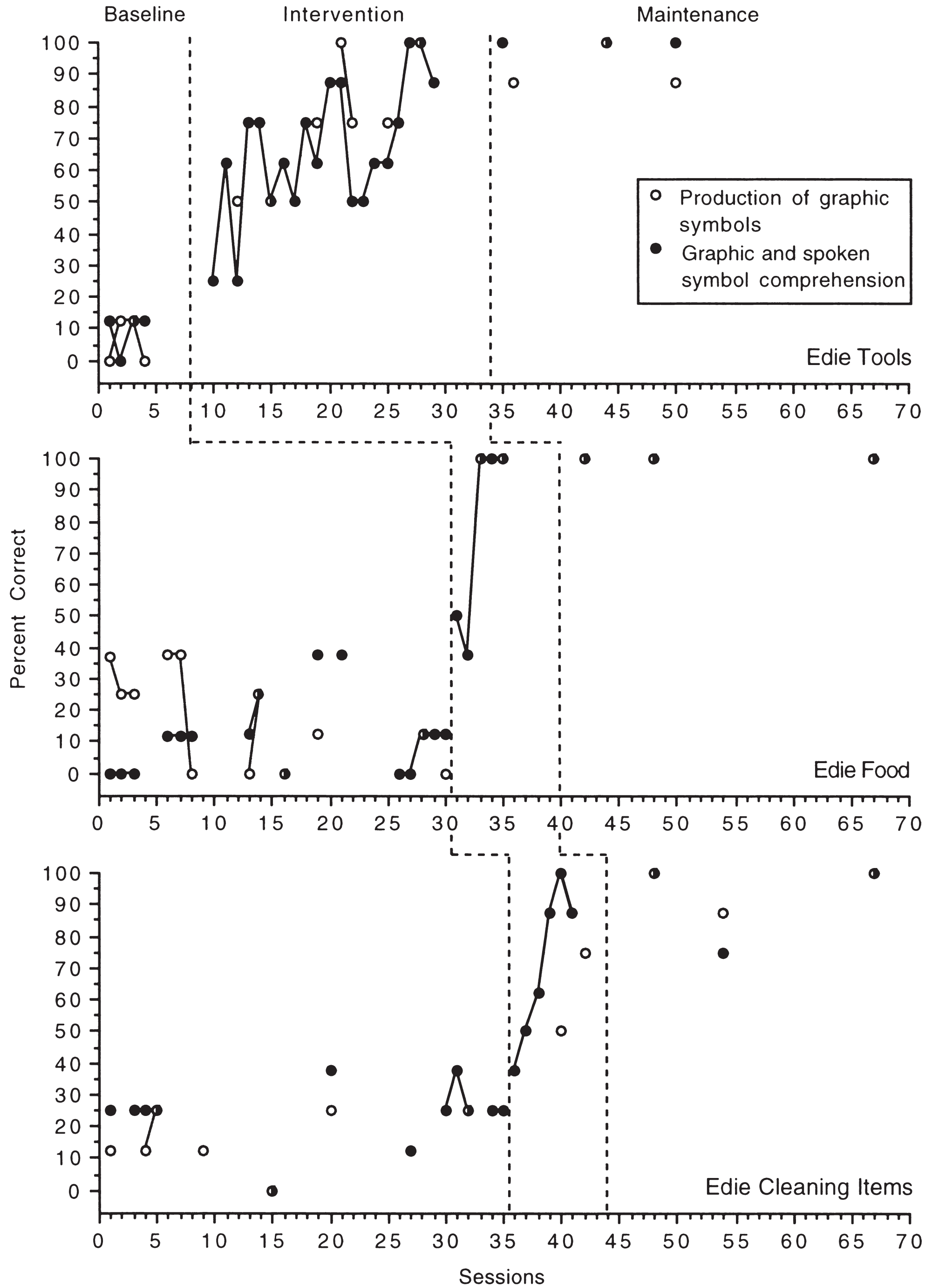
study, comprehension was distinguished from production based on whether the focus of the partner's attention was the graphic symbol or the object (Reichle, Halle, & Drasgow, 1998). A comprehension task was implemented when the experimenter offered a graphic symbol and the individual selected the corresponding object from an array of objects. A production task was implemented when the experimenter offered an object and the individual selected the corresponding symbol from an array of symbols. There is no real parallel to the production task used for individuals who speak (Brady, 2001). Traditionally, many interventionists have assumed that comprehension precedes production (Wetherby, Reichle, & Pierce, 1998). However, there is growing evidence that disputes this more traditional

FIGURE 2. Percent correct for symbol comprehension and production for Niles.



assumption for individuals who use graphic mode communication (Brady, 2000, 2001; Brady & Saunders, 1991). In the current study, Niles showed a faster rate of acquisition for symbol production than for symbol comprehension for Symbol Set 3. During the intervention and maintenance phases, he consistently failed to differentiate *tomato* and *orange*. However, it might have been that the line-drawn symbols representing these objects were more difficult to discriminate than were the plastic replicas of tomato and orange. In this task, Niles needed to discriminate between the choice stimuli (plastic tomato and plastic orange). Second, he needed to discriminate between the sample stimuli (line-drawn symbol of tomato and line-drawn symbol of orange). The investigator presented the choice

FIGURE 3. Percent correct for symbol comprehension and production for Edie.



stimuli together (simultaneous discrimination), while he presented the sample stimuli one at a time (successive discrimination). Evidence suggests that successive discriminations might be more difficult than simultaneous discriminations (Brady & Saunders, 1991; Carter & Eckerman, 1975). Consequently, if Niles found the line-drawn symbols representing tomato and orange more difficult to discriminate than the plastic replicas of tomato and orange, it might account for his slower rate of acquisition for symbol comprehension as compared to symbol production for Symbol Set 3.

The ability to fast-map may influence the effectiveness of aided language stimulation. Romski, Sevcik, Robinson, Mervis, and Bertrand (1995) suggested that individuals who do not show evidence of fast-mapping may require differing amounts and types of language input than individuals who successfully "fast-map." All of the children in the current study were able to fast-map; this may partially account for their success in learning through augmented input. Future research should explore any potential differences in the efficacy of aided language stimulation as a function of fast-mapping ability.

In this study, each child showed evidence of speech comprehension skills before the experiment, as measured by the MacArthur Communicative Development Inventories (Fenson et al., 1993). Individuals who comprehend speech may have knowledge about the relationship between words and their referents (Romski & Sevcik, 1993, 1996). Sevcik and Romski (2002) indicated that speech comprehension provides an essential foundation on which to build productive language competence. Consequently, individuals who do not comprehend spoken words (or who comprehend a very small number of spoken words) may be at significant risk in deriving maximal benefit from aided language stimulation. Future research should examine the effects of aided language stimulation with individuals who have a more limited speech comprehension repertoire at the outset of intervention.

Caution should be exercised when considering the extent to which the results of this investigation can be generalized to the larger population of children with developmental disabilities. The children in this study were required to meet specific inclusionary criteria. This resulted in a fairly homogenous group of children.

During aided language stimulation, Elder and Goossens' (1994) recommended using communication displays that were language rich. These authors suggested organizing communication displays using a much broader range of grammatical categories than were used in this study. The communication displays used in the present study each contained only four black and white symbols representing nouns. Consequently, results of this study cannot be generalized to include other grammatical categories (e.g., adjectives, adverbs, verbs, pronouns). Future research should explore the effect of aided language stimulation on other aspects of semantic and syntactic language comprehension and production.

It is possible that the black and white line-drawn symbols used in this study may have influenced the rate of symbol comprehension and symbol production. Graphic symbols can take a variety of forms that include color photographs, black and white photographs, product logos, line drawings, lexigrams, Blissymbols, Premack-type symbols, and traditional orthography (Fuller, Lloyd, & Stratton, 1997; Mustonen, Locke, Reichle, Solbrack, & Lindgren, 1991). Different symbol collections may vary with regard to iconicity (Mirenda & Locke, 1989). Iconicity refers to the visual similarity between a symbol and its referent (Harrell, Bowers, & Bacal, 1973; Lloyd & Fuller, 1990; Schlosser & Sigafoos, 2002). Iconicity has been demonstrated to influence symbol acquisition (Clark, 1981; Ecklund & Reichle, 1987; Mizuko, 1987). The Picture Communication Symbols (Mayer-Johnson, 1992) used in this study have been shown to be among the most highly iconic aided

FIGURE 4. Percent correct responding to exclusively graphic and exclusively spoken stimuli for Jennie.

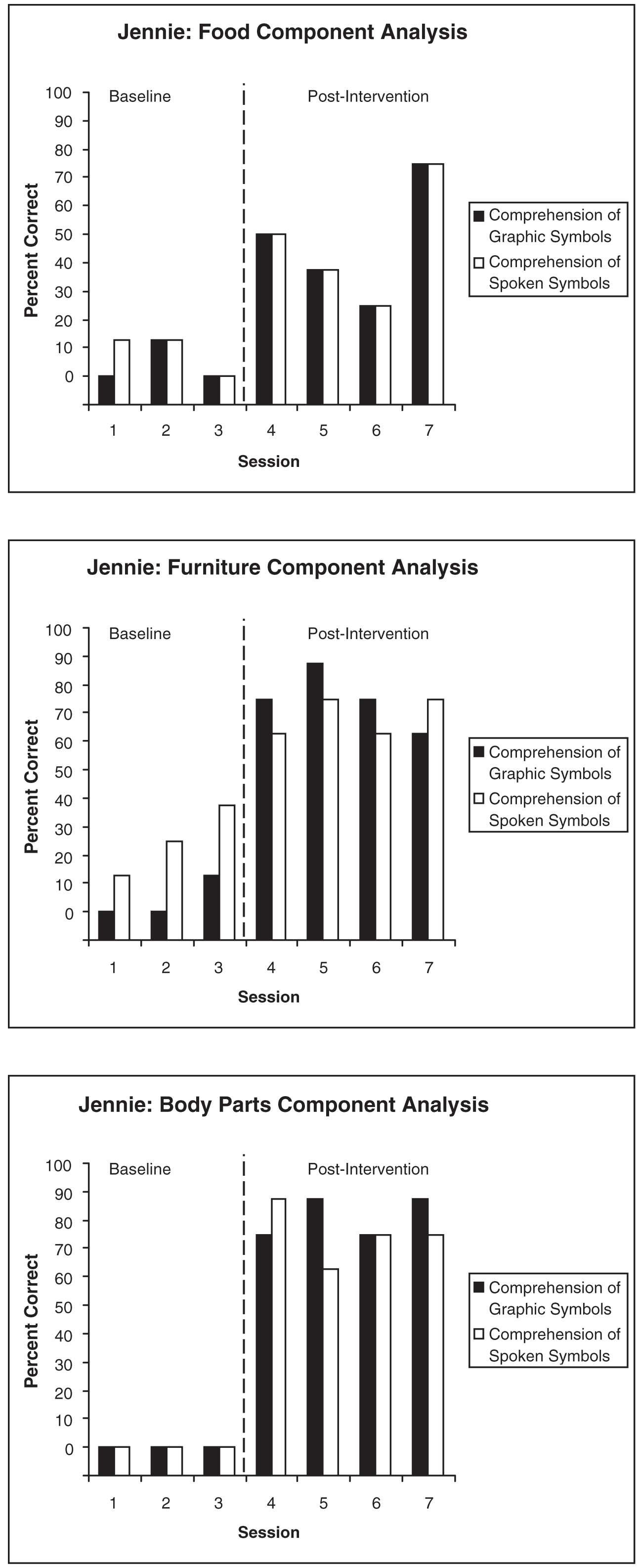


FIGURE 5. Percent correct responding to exclusively graphic and exclusively spoken stimuli for Niles.

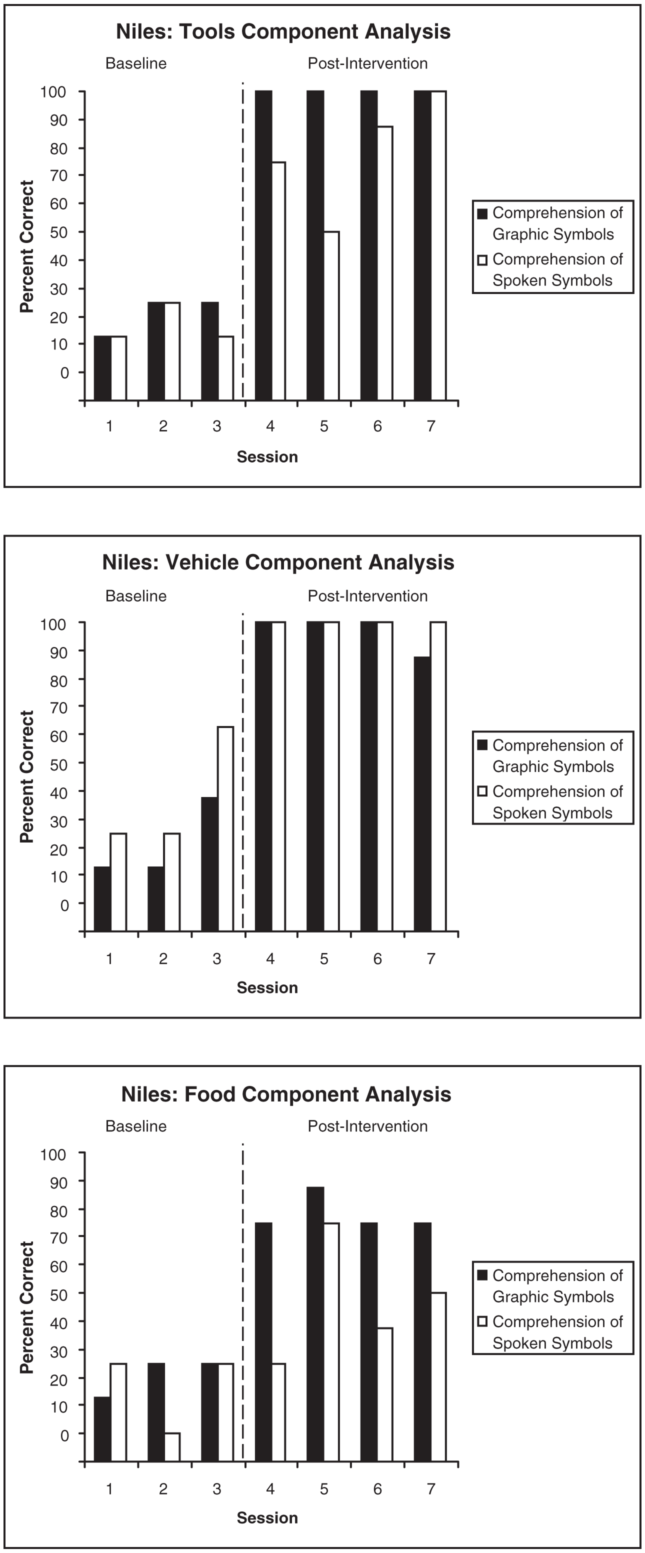
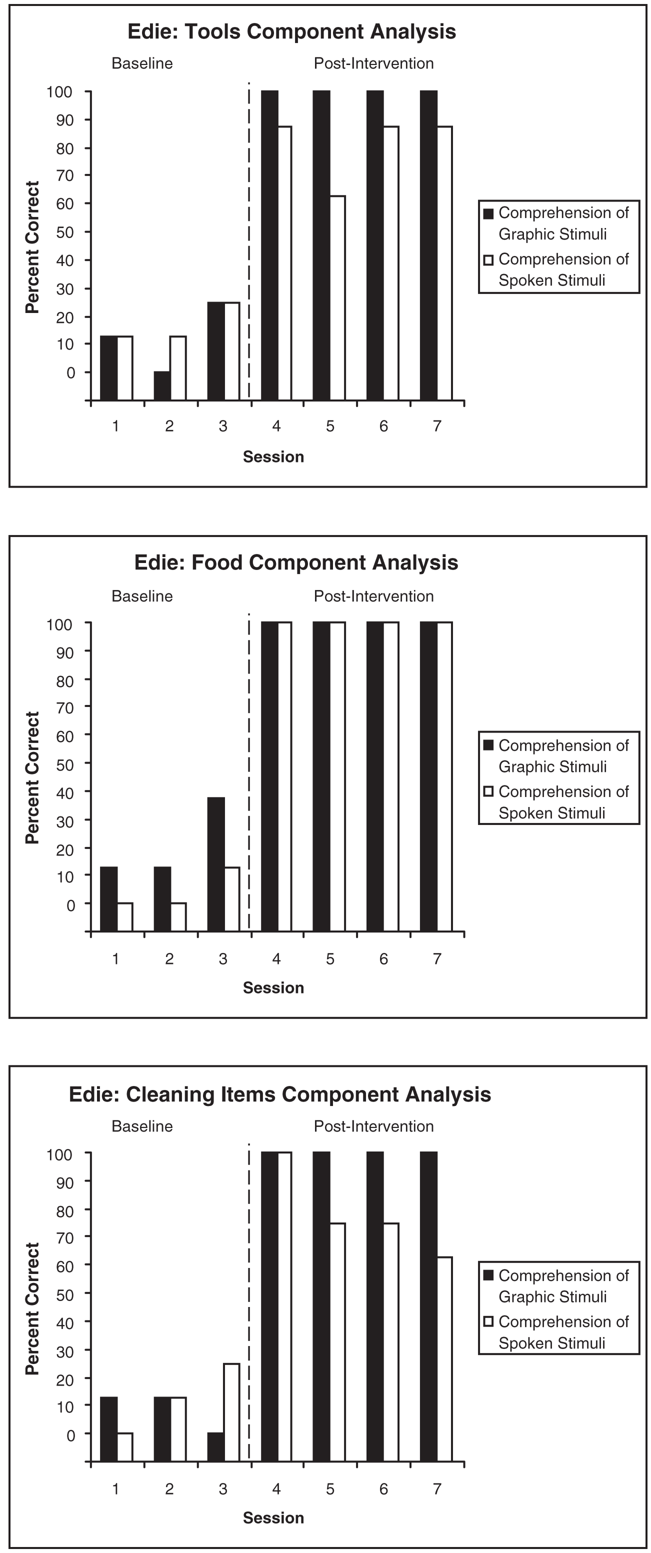


FIGURE 6. Percent correct responding to exclusively graphic and exclusively spoken stimuli for Edie.



symbols (Fuller et al., 1997). It is possible that the use of highly realistic digital photos or less iconic black and white line drawings may have altered the outcome of the current study. Replicating results of the current investigation with other symbol types would enhance the external validity of the outcomes reported in this investigation.

The current study implemented aided language stimulation using graphic symbols and natural speech. Although used in a decontextualized manner, Schlosser et al. (1995) demonstrated that augmented input in the form of synthetic speech resulted in more efficient learning than did augmented input without the use of a VOCA. Future research should determine whether there is a differential effect when using synthetic speech or natural speech during aided language stimulation.

Results of the current investigation suggest that young children with moderate cognitive disabilities can acquire, concurrently, comprehension and production skills as a result of aided language stimulation implemented in the context of scripted routines. Future augmentative communication intervention research should continue to explore the role that more naturalistic intervention procedures can play in establishing an initial communicative repertoire. The effectiveness of aided language stimulation should be compared to the effectiveness of other training programs, including direct instruction, direct instruction embedded within natural contexts, and milieu teaching strategies.

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Contact author: Michael D. Harris, PhD, Department of Communicative Disorders, University of Wisconsin–River Falls, 410 South Third Street, River Falls, WI 54022. E-mail: michael.d.harris@uwrf.edu

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Instructional strategies used in direct AAC interventions with children to support graphic symbol learning: A systematic review

Yvonne Lynch
Manchester Metropolitan University, UK

Muireann McCleary
Central Remedial Clinic, Ireland

Martine Smith
Trinity College Dublin, Ireland

Abstract

Augmentative and alternative communication (AAC) refers to a wide range of aided and unaided modes that are employed with a diverse group of people to support a range of language and communication outcomes. Children whose comprehension of spoken language greatly exceeds their ability to express themselves within that modality can be described as expressive users of AAC.

Interventions are important in promoting language acquisition and the expressive use of graphic symbols. Instructional strategies employed within interventions have an important impact on treatment effectiveness. A systematic review was undertaken to identify instructional strategies that have demonstrated effectiveness in supporting graphic symbol learning and aided language development in direct interventions with children aged 0–18 years who are expressive users of aided AAC (including children without learning difficulties and those with mild-moderate learning difficulties). A comprehensive search strategy was carried out and all studies meeting the inclusion criteria were quality appraised. A data extraction procedure was conducted on the studies meeting the quality appraisal criteria. Fifteen studies were included in the review investigating four instructional strategies used to support graphic symbol learning. The most studied instructional strategy, aided modeling, can be considered an evidenced-based practice. There is also strong research evidence to support the use of both narrative-based interventions and mand-model procedures to facilitate graphic symbol learning and aided language acquisition in children who

Corresponding author:
Yvonne Lynch, Faculty of Health, Psychology and Social Care, Manchester Metropolitan University, Room 1.14 Brooks Building, 53 Bonsall Street, Manchester, M15 6GX, UK.
Email: yvonne.lynch@mmu.ac.uk

are expressive users of aided AAC. However, across the literature reviewed, a lack of consistent terminology hampered the ability to compare studies and draw conclusions. More consistent use of terminology would enhance the utility of the evidence base.

Keywords
aided language acquisition, augmentative and alternative communication, children, instructional strategies, intervention

I Introduction

Augmentative and alternative communication (AAC) can be used to support language and communication in many different ways, using unaided and aided modalities. Unaided communication is expressed through resources internal to the communicator, such as gesture, eye gaze or facial expression. Aided communication involves the recruitment of external resources, such as pictures, graphic symbols or written words, displayed on low-tech communication books or boards, or using high-tech options including speech generating devices (SGDs) and tablet technology. For some individuals, AAC modalities provide essential supports for both language comprehension and expression, a group that von Tetzchner and Martinsen (2000) categorized as alternative users of AAC. This group includes individuals such as those with multiple disabilities who may rely on visual supports both to understand their world and to express themselves within that world. However, AAC may also be introduced to support natural abilities, to augment unintelligible speech in specific situations or at specific points in development. For this group, the expectation is that natural speech may ultimately become a primary mode of communication. Children with learning disabilities or those with a diagnosis of childhood apraxia of speech may belong to this group. Finally, for some children and adults (expressive users in the von Tetzchner and Martinsen classification system), AAC modes provide a primary means of expression, usually to compensate for motor speech impairments (e.g. secondary to cerebral palsy). For this group, spoken language comprehension is relatively intact. The underlying presumption is that children require an expressive means to bypass their motor speech difficulties, but that over the course of development, they construct an internal speech-based language system as a basis for their expressive communication.

In many respects, the path to language and communication development for children who are expressive users of aided communication diverges from that of children who are developing typically. Aided communication development may be characterized by planned rather than spontaneous interactions (Light, 1997; von Tetzchner and Stadskleiv, 2016); communication interactions may be dominated by speaking partners in terms of distribution of the conversational floor (Raghavendra et al., 2012), and children must adapt to an asymmetry in input and output modalities of communication, with spoken language as their primary input mode, but an expectation that graphic symbols will function as the main output mode (Smith, 2006). As a result, language and communication development through augmented means does not occur naturally; rather, it requires specific intervention supports (Therrien et al., 2016).

The aim of any communication intervention is to instigate change, to prevent an undesirable outcome or to positively change the current position (Bunning, 2004). AAC interventions with young children aim to influence the underlying language development in children who use AAC forms (Thistle and Wilkinson, 2015). Intervention may involve a range of activities including direct interventions working with the child who uses AAC or indirect interventions working within the environment to effect change (Granlund et al., 2008). The focus of intervention may vary from targeting generic skills such as switch access, that may be used across multiple activities, (e.g.

accessing an SGD as well as playing a computer game), to targeting AAC-specific skills such as using graphic symbols to communicate (Granlund et al., 2008). As such, AAC interventions are complex and comprise a range of interacting components. It is important to acknowledge that these different elements not only play a part in intervention outcomes in their own right, but may also have an interactive and integrative effect (Sevcik et al., 2009).

While ascertaining the effectiveness of complex interventions can be challenging (Campbell et al., 2007), not least because the contribution of multiple different components may be difficult to disentangle, it is important that clinicians use the available evidence base to inform intervention decisions. The instructional strategies (Beukelman and Mirenda, 2013) or procedures (Fey, 2006) used within interventions to lead to intervention goals are a key element of interventions. Fey (2006) describes intervention procedures (e.g. modeling the target, provision of structured practice, etc.) as the 'active ingredients of the intervention'. Given the resource demands of AAC interventions, it is imperative that the instructional strategies employed are both effective and efficient. While evaluating individual components of interventions in isolation may reduce the external validity of effectiveness research, it may provide useful indicators in selecting the most appropriate strategies to use in clinical practice. The aim of this systematic review is to identify instructional strategies that have demonstrated effectiveness in supporting graphic symbol learning and aided language development in direct interventions with children who are expressive users of AAC.

II Research question

What instructional strategies are effective in supporting graphic symbol learning and aided language development for children who are expressive users of AAC?

III Method

1 Search procedure

A multi-faceted search strategy was designed to identify relevant literature. Searches were conducted across four databases: Psychinfo (behavioural and social sciences), ERIC (education), CINAHL (nursing and allied health) and Pubmed (biomedical) to reflect the interdisciplinary nature of the AAC field (Schlosser et al., 2005). The database searches were supplemented by hand searches of the journal *Augmentative and Alternative Communication* and the *Journal of Speech, Language and Hearing Research* and citation searching. The search terms used were:

- 'Augmentative and Alternative Communication' AND 'Intervention'
- 'Aided Language Stimulation' AND 'Intervention'
- 'Aided Language' AND 'Intervention'
- 'Augmented Language Intervention
- 'Graphic Symbols' AND 'Intervention'

2 Inclusion criteria

a Publication date and language. Studies written in the English language and published between 1992 and 2016 were included in the review. The initial searches were conducted on 30.12.2012. Given the rapid developments in technology over the previous two decades, a 20-year period was selected to capture interventions involving aided communication across this era of technological innovation. The searches were repeated and updated on 10.12.2016.

b Participants. Study participants had to meet the criteria of (1) having a receptive-expressive language gap (with comprehension exceeding expression to comply with the categorization of expressive user of AAC), and (2) a developmental disability, (3) be aged 0–18 years and (4) with no identified social communication impairment. Studies for which participants did not meet the criteria for expressive user of AAC were excluded. Studies involving participants with a primary diagnosis of autism spectrum disorder (ASD) were excluded given that a social communication impairment forms part of the diagnostic criteria (American Psychiatric Association, 2013), and children with severe to profound intellectual disabilities were excluded as they are likely to use AAC to support both expression and comprehension. Studies with both eligible and ineligible participant data were only included if the results could be disaggregated.

c Intervention. Interventions within the area of AAC focused on graphic symbol learning and aided language acquisition were evaluated. All studies using direct intervention methods (i.e. that involved direct intervention with a target child) with the aim of developing graphic symbol learning or aided language acquisition were included. Indirect interventions such as communication partner training were excluded. Studies of challenging behaviour interventions, requesting/rejecting interventions and perceptions of interventions were excluded, as these studies did not address the process of graphic symbol learning. Similarly, studies that investigated AAC as a speech development technique were excluded. Finally, studies on the Picture Exchange Communication System (PECS) were also excluded. Bondy and Frost (1994) describe PECS as a programme to teach children with ASD a functional communication system. Given that PECS is primarily used with a population that had been excluded from the review and as it is a multifaceted approach that utilizes a specific communication context, these studies were excluded.

d Outcomes. Studies reporting outcome data on graphic symbol learning (receptive or expressive), symbol recall, the expressive use of graphic symbols (through the use of AAC), or outcome data on language acquisition in children using graphic-symbol-based AAC systems were included. Studies reporting outcomes related to specific operational competencies (e.g. how to use a scan pattern) were excluded. Studies that only reported outcomes related to literacy attainment were also excluded. However, studies with outcomes related to language and literacy were included, although only the data related to language achievements were evaluated. Papers that did not have outcome measures related to graphic symbol learning or aided language acquisition were excluded. Figure 1 details the search results across each stage of the systematic review.

3 Screening process

The search process yielded 1,756 records that were imported into Endnote for screening. The first author conducted a title and abstract review followed by full text review. Exclusion reasons were coded in a Participant, Intervention and Outcome format. Inter-rater reliability was conducted at the full text review stage. Two independent raters were provided with guidance and asked to review a sample of ten papers each (five of which had been included and five of which had been excluded by the first author). 100% agreement was attained across all studies screened.

4 Quality appraisal

The inclusion/exclusion criteria were used to screen all returned records and sixty-six studies were identified for full text review. Full text review identified 24 studies for quality appraisal. Quality

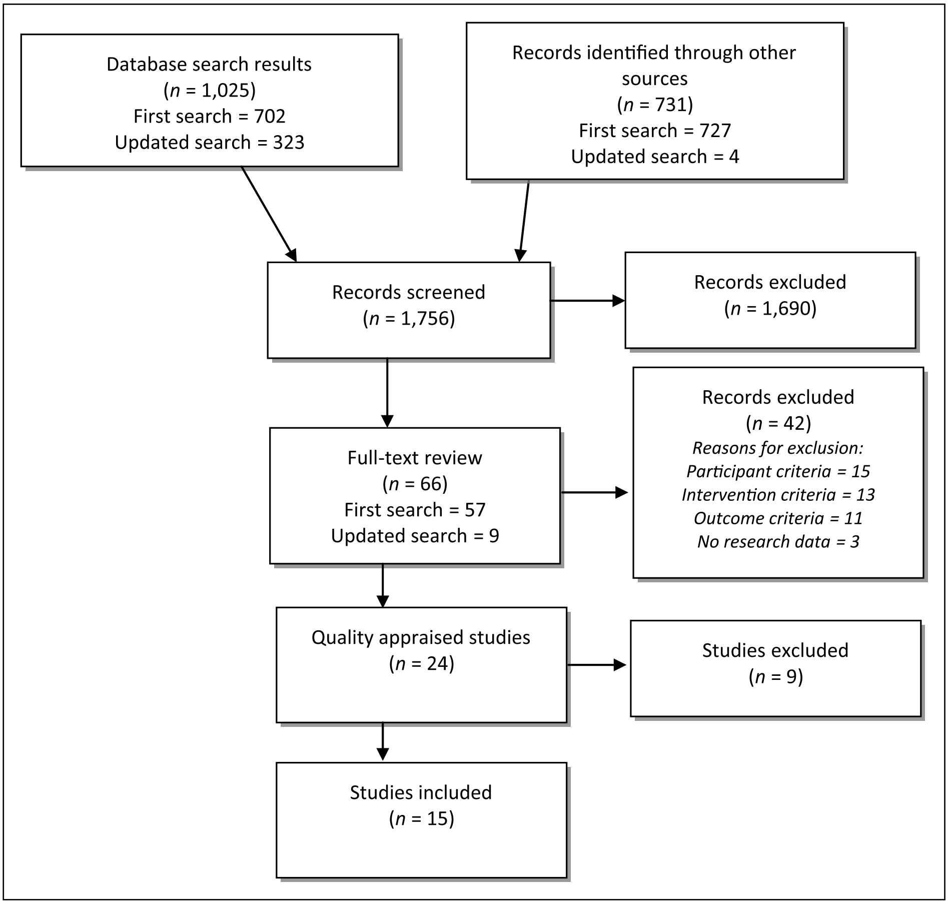

Figure 1. Search results flowchart.

indicators were derived from Reichow et al.'s (2008) method. This evaluation tool can be used to evaluate methodological rigour and categorizes studies as strong, adequate or weak based on primary and secondary quality indicators (including specification of dependent variable, independent variable, visual analysis, fidelity and social validity). Fifteen studies attained ratings of adequate or strong and were included in the review. Nine of the 24 studies in the quality appraisal were categorized as weak according to Reichow et al.'s criteria (i.e. they attained fewer than four high-quality ratings on primary quality indicators or showed evidence of less than two secondary quality indicators). Studies attaining a weak rating were removed from the review (see supplemental material for full details of quality appraisal ratings).

The included studies were also appraised collectively. Horner et al. (2005) propose that in order to be considered evidence-based, a practice must have a minimum of five single-subject studies that meet acceptable level of methodological rigour and quality criteria and that are published in peer-review journals. In addition, studies must be conducted by at least three different researchers across three or more geographical locations and must collectively include a minimum of 20 participants (Horner et al., 2005). This standard was applied to the studies in the present review to ascertain if the instructional strategies investigated can be considered evidence-based practices.

5 Inter-rater agreement

Seven AAC clinicians applied the criteria to the 24 studies considered for the review. Each clinician independently carried out quality appraisal of at least two studies. Discrepancies between raters arose across four studies. These studies were appraised for a third time by an independent rater. Where there was 100% agreement between two of three raters, their agreed rating was applied.

6 Data extraction

A data extraction template was developed based on the research question and used to extract the following study characteristics: sample size, age and diagnosis of participants, primary focus of intervention, instructional strategies used, dosage (i.e. the amount and frequency of intervention), outcome measures used and intervention outcomes. Table 1 sets out the data extracted from the 15 studies in the review. The studies were published from 1995–2015.

IV Results

Across the 15 included studies, four instructional strategies were identified, that met the criteria for provisional consideration as effective in supporting graphic symbol learning and/or aided language acquisition. These strategies are:

- Aided AAC modeling: the provision of augmented input alongside spoken language in naturalistic settings (Sennott et al., 2016)
- Narrative-based interventions: the provision of aided AAC modeling and language elicitation techniques embedded in a narrative routine.
- An eclectic approach: the provision of communication opportunities, and aided AAC modeling with least to most prompt hierarchies to facilitate symbol production.
- A mand-model instructional strategy: the provision of clinician-led communication opportunities with a hierarchy of prompts. Children were asked to produce graphic symbol output; if they did not respond to prompts, a model was provided.

Each instructional strategy studied incorporated a number of techniques to support aided language acquisition and graphic symbol learning. While there was some overlap across strategies, the manner in which they were used and the aim of the strategies varied. For example, aided language modeling primarily focused on re-balancing the input-output asymmetry experienced by children who use AAC and symbol output by the child was not directly targeted. Narrative interventions and eclectic approaches focused on both augmented input and on elicitation of symbol output. Finally, in the mand-model strategy, the focus was on symbol production/selection as a means to learn target linguistic structures. The included studies provide evidence of the effectiveness of these four instructional strategies in supporting learning across a number of domains as detailed below.

1 Aided language modeling (studies 1, 2, 3, 5, 6, 8, 10 and 14)

Over half the included studies examined aided modeling strategies. The included studies suggest that the use of augmented input is supportive of symbol comprehension (Dada et al., 2009; Harris et al., 2004), expressive symbol production (Harris et al., 2004; Iacono and Duncum, 1995;

Table 1. Data extracted from the 15 studies in the review.

Number	Study	Participants	Communication systems	Focus of Intervention	Instructional strategies used	Dosage	Outcome measures used	Intervention outcomes
1	Binger and Light (2007)	3 male; 2 female; 3–5 years; Syndromes (3); Developmental delay and suspected CAS (2); Significant speech impairment; Expressive vocabularies <25 words; 2-word level comprehension; Prior AAC exposure	Speech Manual signs; Communication aids (3); Communication boards (2)	Multi-symbol utterances	Modeling	Criterion based on 15-min sessions	Video analysis	4 out of 5 increased number of multi-symbol utterances
2	Binger et al. (2011)	2 male; 1 female; 5–12 years; Cerebral palsy (2); Childhood apraxia of speech (1); Speech intelligibility of less than 50%; AE < 3 years on the TACL-R	Vantage or vanguard aid with Unity 45	Grammatical morphemes	Modeling and recasts	Criterion based on 10–15-min session (maximum 7 sessions)	Multiple probe of grammatical morphemes	Contrastive targets were beneficial and a short intervention time was needed to acquire morphemes
3	Dada and Alant (2009)	1 male; 3 female; 8–12 years; Cerebral palsy (3); Down syndrome (1); Fewer than 15 intelligible words and no previous AAC experience	Provided with communication boards for the study	Receptive vocabulary	Aided language stimulation	15–25 mins daily for 3 weeks	Multiple probes of receptive vocabulary	Strategy supportive of learning target vocabulary
4	Edmister and Wegner (2015)	3 female; 7–9 years; Cerebral palsy (2); Microcephaly (1)	Dynavox aids; Gestures; Vocalizations; Emerging literacy skills	Expressive language	Narrative-based intervention	17–23 sessions	Mean number of turns using device	Initial increase in turns but then declined
5	Harris and Reichle (2004)	1 male; 2 female; 3–5 years; Moderate cognitive disability (1); Down syndrome (2); Functionally non-speaking	AAC experience not specified	Symbol comprehension and production	Aided language stimulation	Criterion based on 80–90 sessions	Comprehension and symbol production probes matching symbols to their referent objects	Improved symbol comprehension and production for object symbols; Increased rate of symbol learning after the first symbol set

(Continued)

Table 1. (Continued)

Number	Study	Participants	Communication systems	Focus of Intervention	Instructional strategies used	Dosage	Outcome measures used	Intervention outcomes
6	Iacono and Duncum (1995)	1 female; 2;8 years; Down syndrome and a mild hearing loss; Limited expressive output – using 6 manual signs expressively	Dynavox aid was introduced for the study	Expressive language	Child-led play activities with models, expansions and contingent praise	6 sessions over 3 weeks	Number of words and word combinations produced in any modality	More words and word combinations produced in VOCA condition
7	Johnston et al. (2003)	1 male; 2 female; 3–4 years; Developmental delay (1); Cerebral palsy and developmental delay (1); Severe multiple disabilities (1)	Single switch aids and graphic symbols	Expressive language	Eclectic approach	Not specified	Multiple probes	All three improved on targeted goals (symbol and verbal goals)
8	Kent-Walsh et al. (2015)	2 male; 1 female; 4–6 years; Severe speech impairments; Hearing and vision WNL; Expressive vocabularies 50 words+ (aided or unaided); Using grammatically incomplete utterances	AAC; i-pad experience	Expressive language	Modeling	Criterion based on 5–14 sessions	Aided productions of aux verb + intransitive verb	All three made gains in productive use of targets
9	Nigam et al. (2006)	1 female; 13 years; Moderate learning impairment, orthopaedic impairment communication disorder	Yes/no response; Facial expression; Symbol board; Dynavox	Symbol combinations	Mand-model strategy	Criterion based on 30 mins, 3 times a week	Assessment probes for targeted rule	The participant generalized an early syntactic rule
10	Solomon-Rice and Soto (2014)	2 male; 1 female; 2–3 years; Developmental delay (1); Extreme prematurity and developmental speech-language delay (1); Developmental speech-language delay (1)	Facial expression, Gestures; Word approximations/ speech; Visual grid displays (2); Communication board (1)	Expressive vocabulary	Focused stimulation versus Augmented input	Criterion based on 20 mins per session (6–24 sessions)	Expressive use of target vocabulary in any mode	Both strategies effective for 2 out of 3 (especially effective if symbol comprehension is already present)

Table 1. (Continued)

Number	Study	Participants	Communication systems	Focus of Intervention	Instructional strategies used	Dosage	Outcome measures used	Intervention outcomes
11	Soto and Dukhovny (2008)	1 female; 7 years; Congenital neurological disorder	Vocalizations yes/no response; Modified sign language; Vantage II aid	Expressive vocabulary	Narrative-based intervention	60 mins, 3 times a week for 6 weeks	Multi-symbol utterances	Increase expressive vocabulary and multi-symbol utterances
12	Soto et al. (2009)	3 female; 7–9 years; Cerebral palsy (2); Severe verbal apraxia (1)	Vocalizations (1); some words/phrase approximations (2); Yes/No response (3); symbol books (3); Vantage II (3)	Narrative skills	Narrative-based intervention	50–60 mins, 2 a week for up to 6 months	Linguistic complexity; Narrative complexity	Improved narrative skills (story elements); Increase in linguistic complexity (number of words, number of different words)
13	Soto et al. (2008)	1 female; 12 years; Cerebral palsy	Vocalizations word approximations, gesture eye gaze symbol book; Vanguard aid (Unity 84)	Narrative skills	Narrative-based intervention	3 times per week for 6 weeks	Linguistic complexity; Narrative complexity	Increase in number of words used, expressive language diversity, clausal usage and density; Increase in story complexity (plot structure, cohesion coherence)
14	Taylor and Iacono (2003)	1 male; 3;6 years; Mild intellectual impairment and severe speech impairment	Vocalizations; Manual signs; Previously had a symbol board	Spontaneous symbolic productions	modeling	30 mins, 3 per week for 24 sessions	Symbolic communication acts per minute	Increase in symbolic communication acts in VOCA condition but not in sign only
15	Tönsing et al. (2014)	3 male; 1 female; 6;5–10;8 years; Cerebral palsy (3); Neurological disorder (1)	Vocalizations; Word approximation; Gestures Symbol book (1)	Target multi-symbol utterances	Mand-model strategy	18 sessions	30 probes of intervention symbol combinations	2 showed good progress and 2 showed limited progress

Notes. CAS = Childhood Apraxia of Speech, TACL-R = The Test for Auditory, VOCA = Voice Output Communication Aid, WNL = Within Normal Limits.

Solomon-Rice et al., 2014; Taylor et al., 2003) and the use of multi-symbol utterances and word combinations (Binger et al., 2011; Iacono and Duncum, 1995). The studies also suggest aided modeling may facilitate acquisition of language structures such as grammatical morphemes (Binger et al., 2007) and auxiliary verb and intransitive verb combinations (Kent-Walsh et al., 2015). The studies on aided modeling were also considered collectively using Horner et al.'s (2005) criteria for determining if a practice can be considered evidence based. Aided language modeling met all the criteria to be considered evidence-based and it was the only strategy in the review to meet all the required criteria.

2 Narrative-based intervention (studies 4, 11, 12 and 13)

Four studies examined narrative-based interventions. Three studies reported increased linguistic complexity in the aided output of participants post-intervention. Participants demonstrated increases in the number and diversity of symbols produced and an increased use of multi-symbol utterances (Soto et al., 2008, 2009). Two studies also reported an improvement in narrative complexity (with outcomes of improved plot structures and increased cohesion and coherence) (Soto et al., 2008, 2009). The fourth study explored the effect of repeated storybook reading on the number of communicative turns (Edmister et al., 2015). Although two out of three participants initially demonstrated an increase in their use of symbol-based communicative turns, these gains were not maintained across the intervention.

Narrative-based instructional strategies may be effective in supporting expressive language development; however, caution is needed in generalizing from these findings due to the small participant numbers across the included studies for this instructional strategy and the variable profile of gains across participants.

3 Eclectic approach (study 7)

Johnston et al. (2003) applied an eclectic approach (i.e. increased communication opportunities, aided modeling, hierarchy of prompting) that they reported supported three participants in achieving targeted goals and in increasing expressive communication (both verbal and symbol-based).

4 Mand-model procedure with matrix strategy (studies 9 and 15)

Two studies applied a mand-model procedure. One explored the use of a mand-model procedure to support the acquisition of an Action+Object rule using graphic symbols (Nigam et al., 2006). One out of three participants met the inclusion criteria of the current review. That participant learned the Action+Object rule and was able to generalize it to combinations of graphic symbols not targeted in the intervention. In the second study (Tönsing et al., 2014), three out of four participants increased production of multi-symbol combinations targeted and generalized to non-trained exemplars. The remaining participant did not reach criterion in the maximum number of sessions, a profile the authors suggest may have been related to distractibility and disengagement with the intervention activity. These two studies suggest that a mand-model strategy may be supportive of expressive aided syntax development.

V Discussion

At the heart of AAC interventions for children must be a focus on supporting linguistic development and expressive communication through aided means. The present review suggests the evidence base for instructional strategies to promote language development is emerging. However, further research is warranted to enable clinicians to choose optimal instructional strategies.

Considering the studies collectively, one strategy, aided modeling, met Horner et al.'s (2005) criteria as an evidence-based practice. Given that one of the challenges faced by children acquiring language using aided communication is that they receive input primarily through speech but must express themselves using graphic symbols, the effectiveness of aided modeling as a strategy may derive from the fact that it offers an opportunity to observe competent language users using symbols for communication and to receive symbols as input. Indirect benefits may derive from the fact that aided modeling may require communication partners to slow their rate of speech and may highlight for them the challenges of using aided communication leading to other positive communication behaviours (Smith, 2015; von Tetzchner and Stadskleiv, 2016). To have one instructional strategy meet criteria for evidence-based effectiveness is a step forward and lends support to clinicians in advocating for augmented input across communication settings. While the remaining three strategies did not meet the criteria set down by Horner et al, they nonetheless seem promising. As these interventions incorporated use of aided modeling as one instructional strategy, it is not possible to determine whether the additional components (increased communication opportunities and language elicitation techniques) represent 'added value' as independent instructional strategies, or whether the benefit of this intervention approach is related to the provision of a context into which aided language modeling can be readily imported. Similarly, both the eclectic approach and the studies involving use of mand-model procedures incorporated some use of aided modeling, although in the case of mand-model procedures the focus was on specific linguistic targets within structured teaching contexts.

Unlike the studies focused on aided language modeling, the narrative-based, eclectic and mand-model studies all incorporated a focus on symbol production as well as aided modeling. Production opportunities may represent important contexts for learning that complement what is available through aided modeling (Smith, 2015). What is not clear from the available evidence base is whether the benefits of these strategies apply equally at all stages of aided language development, or whether there may be differential benefit from selected use of a specific strategy at key points in development (Nelson, 1992).

Although the current review provides some support for use of four instructional strategies to support graphic symbol learning and aided language development, it does not address the question of relative effectiveness and efficiency. As no comparative studies were identified in the review, it was not possible to compare any of the identified strategies in terms of effectiveness and efficiency. The majority of the studies in the review focused on naturalistic strategies which may take advantage of naturally occurring communicative opportunities. A criticism of naturalistic strategies is they may not provide the range and quantity of linguistic opportunities as more structured clinician-led strategies. While the evidence base is emerging, it warrants further development to enable clinicians to make informed decisions for their clients.

VI Limitations

The present review has a number of limitations that must be acknowledged. First, some of the search criteria decisions introduced biases, namely a language bias and a publication bias (only English language studies published in peer-reviewed journals were included). Second, the review focused on children who are expressive users of AAC. This group was chosen to allow a concentrated consideration of graphic symbol learning in children who are primarily using aided AAC as an expressive mode. Therefore, the findings are not applicable to other groups of children and adults who use AAC (for example, those who use AAC to support comprehension and expression) or to other outcomes (for example, the impact of AAC on speech development). Third, the studies provided limited information on the stages of aided development in the child participants studied. The review suggests that naturalistic strategies are supportive of graphic symbol learning. However, it is not possible to comment on whether naturalistic strategies are particularly effective at different stages of aided language development or if other strategies may be more effective for particular aspects of aided language learning. Further research is warranted to compare the effectiveness of instructional strategies at different stages of aided language acquisition. Finally, the variable use of terminology across the AAC literature presented challenges in identifying studies for inclusion in the review. As a result, a number of additional searches were conducted to ensure search robustness. Furthermore, the variability in terminology used across the literature presented difficulties in evaluating the studies. Different terms were used to describe the same or similar strategies (for example, modeling and aided language stimulation) (see also Sennott et al., 2016). Due to the lack of consistent use of terminology, drawing conclusions across studies was challenging. For example, the study by Dada and Alant (2009) was the only one to define aided modeling (aided models were presented with spoken language input at least 70% of the time and a ratio of 80:20 of statements to questions). Even though many of the studies described the intervention undertaken and addressed treatment fidelity, there were assumptions in many studies that the strategies outlined required no operational definition. The variability in the use of terminology and the difficulty ascertaining how exactly terms should be interpreted across studies presents a real challenge to the field in terms of building an evidence base.

VII Conclusions

Interventions to support the needs of children who rely on aided communication are complex and multi-faceted. Based on a small but emerging evidence base, this review suggests that at least four intervention strategies are potentially effective in supporting graphic symbol learning and aided language development. These strategies essentially rest on provision of accessible input in meaningful linguistic contexts, mirroring the findings from research with children with language impairment (Fey, 1986). However, in order to be fully effective, such strategies must be embedded in interventions that reflect the complexity of interactions involving aided communication and focused on enhancing participation rather than addressing development of isolated skills.

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ORCID iD

Yvonne Lynch https://orcid.org/0000-0003-3209-3099

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Note. Studies included in the review are denoted with an asterisk.

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Limitations with Using a Representational Hierarchy Approach for Language Learning

Gayle Porter & Linda Burkhart

The assumption that photos are easier to learn than pictographs is based on the representational hierarchy of which symbol is more iconic or easier to recognize or guess at the meaning, without any prior learning. A lot of us learned about the representational hierarchy in our AAC courses and the role of iconicity in symbol learning has been a focus at different times in the AAC literature. However, as we have shifted our focus to children learning to communicate and learning language in natural contexts, it is apparent that using the representational hierarchy has some significant limitations for aided language acquisition (as opposed to guessing symbols). Romski and Sevcik (2005) refer to the representational hierarchy as one of the myths that have limited aided language learning possibilities.

Some of the issues with using the representational hierarchy as a basis for aided language intervention (including assuming that photos need to be used prior to pictographs) include:

- Photo iconicity only relates to representational nouns (picture producing words). PROBLEM for AAC – this has led to an overemphasis on noun only vocabulary to the exclusion of other, often earlier acquired, and potentially more powerful, vocabulary such as GO, COME, STOP, HELP, NO, MORE, MINE.
- More concrete representations such as objects and photos can actually make the use of these as symbols for communication purposes more difficult. E.g. As the photo of a particular cup visually has so much in common with just that cup it can be very difficult to use it to represent the more general concept of drink (which may come in any number of cups). This also complicates attempts to create photographic representations for non-picture producing words. For example, a photo of a man with his hand held up in a stop gesture, has such strong visual associations representing MAN that it may be more difficult to assign the meaning STOP to this photo (i.e. the photo more naturally produces the word MAN in a person's mind). In the past, when we used photos for people in PODD we found children and partners getting distracted from the message they were communicating by discussion of the photos (like looking in a photo album).
- Most picture producing words are lower frequency (extended / fringe vocabulary) rather than core vocabulary which is frequently used in multiple situations. This means you get less communication out of each symbol and less opportunity to learn and use words in multiple environments and situations.
- Photos of nouns are more recognizable than line drawings by individuals who have typical visual perceptual skills. Children who have damage to the cortical areas of the brain that process vision – Cortical Visual Impairment (CVI), may have great difficulty with the complexity of photographs. Problems dealing with visual complexity is a common characteristic of children who have CVI (Roman-Lantzy, 2007). The amount of details and the number of colors in a

stimulus all increase the complexity of an image. The more complex the image, the less likely that a child with CVI will look at it, and over time, be able to derive meaning from it. Photographs are among the most complex visual images for many of these children. Images that have only one or two colors, simple shapes that are presented to the child on a blank field (usually black) without other environmental visual clutter, will be more likely to interest the child visually, and therefore have a better chance of being associated with meaning through use. The visual clutter of a photograph can also be distracting for some children on the autism spectrum who may find it difficult to filter out extraneous information and focus on the part or parts that are most relevant to the meaning.

- Degree of iconicity – how easy it is to recognize, guess at the meaning of a symbol without any input - is not is not the issue in language acquisition. **Language is learned.** Why can an English speaker understand/read/speak English and not Greek? Symbols for spoken and written Greek words are no more or less arbitrary than spoken or written English – the difference is that they have had the opportunity to learn English speech and text.
- Research into the natural acquisition of sign languages and arbitrary gestures has demonstrated that iconicity of the symbol /sign does not influence first word learning in young children. The use and usefulness of the symbol/sign is more important than the iconicity. (Namy, Campbell & Tomasello, 2004, summarize some of the relevant research in this area)
- Speech is really arbitrary (equivalent to spelling) and very young children learn to understand and use speech through exposure in daily life.
- The primary problem with using the representational hierarchy as a basis for aided language intervention is that the **iconicity of symbols is not an important factor in early language acquisition**.
- The tendency to look at iconicity with an overemphasis on nouns tends to narrow communication to choicemaking, which is not the same as communication autonomy - a person saying what they want to say, when they want to say it - and it is unlikely to stimulate language acquisition.

So with this information we do not wait to introduce pictographs, but begin by using receptive input in genuine, meaningful contexts to provide the student with the opportunity to learn the symbols. The aim is to stimulate communication and language development to support children in learning to communicate for the same purposes and functions as their speaking peers. PODD provides a way to engineer this vocabulary so that others can provide this receptive input to the child who is learning the language. Our experience with very young children (cognitively able children with complex communication needs at 12-13 months expressively using pictographs after a relatively short period of input) and students who have severe and profound cognitive and receptive (spoken) language challenges who have been provided with receptive input (aided language stimulation often over a longer period of time) in pictographs is informative. These children's first expressive words tend to include a large proportion of core (non-picture producing) words such as I DO, STOP, HELP, HURRY UP, MORE, FINISH, I LIKE THIS, SOMETHING'S WRONG. Currently there are more research studies being published that confirm that individuals of various ages and disabilities can learn pictographs via aided language stimulation (Barton, Sevcik, & Romski, 2006; Beck Stoner, & Dennis, 2009; Binger & Light, 2007; Bruno, & Trembath, 2006; Cafiero, 2001; Dada, & Alant, 2009; Drager, Postal, Carrolus, Castellano, Gagliano & Glynn, 2006; Goossens', 1989; Harris, & Reichle, 2004; . Romski, Sevcik, Robinson & Bakeman, 1994; Romski, Sevcik, Robinson, Mervis, & Bertrand, 1995).

Having said all this, there is nothing wrong with using photos to make choices between specific things that can be easily represented with a photo. We don't often feel the need to do this because

- Taking and editing photos to reduce visual complexity takes time, which can limit the amount of vocabulary that is made available to the child for choices
- One can often teach children to more effectively, flexibly and spontaneously use objects in the environments (don't have to be prepared to communicate about a specific thing when it is present)
- Most picture producing words that you can photograph are also relatively easy to learn in pictographs.

The big problems occur when people rely on recognition only and do not give the children a chance to learn language and communicate for a range of purposes. The use of aided language stimulation (other people modeling aided symbols to communicate genuine messages in naturally occurring contexts throughout their day) provides children with the opportunity to learn not only symbols, but also how they could use these symbols for autonomous communication - to say what they want to say, when they want to say it.

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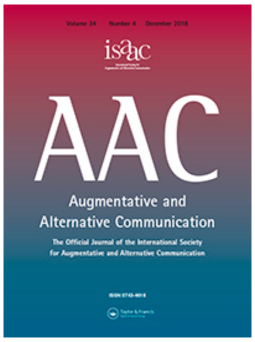

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RESEARCH ARTICLE

Visual-graphic symbol acquisition in school age children with developmental and language delays

Rose A. Sevcik, Andrea Barton-Hulsey, MaryAnn Romski and Amy Hyatt Fonseca

Georgia State University

ABSTRACT
Augmented language systems have become both an integral component of communication intervention programs for children with severe communicative impairments and spurred research on their language and communication development. This study examined intrinsic and extrinsic factors that may influence the language development process for children with developmental disabilities, by exploring the relationship between varying degrees of symbol arbitrariness and extant speech comprehension skills in the discrimination, learning, and use of symbols for communication. For the study, 13 school-aged participants ($M = 8.24$ [years; months]), with both developmental and language delays, were provided experience with iconic Blissymbols and an arbitrary symbol set of lexigrams via observational computerized experience sessions. There was a modest difference in their ability to learn arbitrary versus iconic symbols. There were no differences if the vocabulary item was unknown prior to the symbol learning experience. These findings suggest that iconicity of a symbol may not be a critical factor in learning a symbol-referent relationship if a target referent is not yet known in comprehension.

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Iconicity; developmental disabilities; intervention; comprehension; graphic symbols

In contrast to what is known about the language ability of children with typical development (e.g., Adamson, 1996; Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979; Bruner, 1983; Nelson, 1985), the process of early language development in children with established disabilities and severe communication impairments is still being understood (Abbeduto, McDuffie, Thurman, & Kover, 2016; Barrett & Diniz, 1989; Bonvillian & Nelson, 1982; Burack, Russo, Green, Landry, & Iarocci, 2016; Sevcik & Romski, 2016). Language acquisition is a complex process requiring an individual to develop meaningful symbol referent relationships. By 12–15 months of age, children with typical development comprehend around 50 words (Benedict, 1979; Snyder, Bates, & Bretherton, 1981) and begin to verbalize this symbolic understanding with their first spoken words soon thereafter. For these children, comprehension of language appears to emerge effortlessly and is soon overshadowed by the growing number of spoken words used daily (Sevcik, 2006). For children with established disabilities and severe communication impairments who do not develop spoken language, comprehension and production of language is much more complex. Augmentative and alternative modes of communication (AAC) utilizing specific symbols that augment or substitute for spoken language have been employed in conjunction with specific instructional approaches to achieve functional communication skills (e.g., Romski & Sevcik, 1988).

During the past three decades, augmented language systems have not only become an integral component of communication intervention programs for children with severe communicative impairments but also have spurred innovative research on language and communication development in this group. Practitioners and scholars alike have asked many questions related to the symbols themselves as a medium to teach language to children with severe disabilities (Schlosser & Sigafoos, 2002; Stephenson, 2009; Stephenson & Linfoot, 1996). A representational understanding between a symbol and its referent must be made in order to communicate effectively with an AAC system. This seamless process that typically developing children acquire by 12–15 months of age is more complex in children who use augmented communication systems. Many factors, intrinsic and extrinsic, are involved in the processes children with developmental and language disabilities use to learn symbol-referent relationships. Children who use AAC encompass a broad range of communicative skills and abilities and may vary in the types of instructional strategies needed to learn to use visual-graphic symbols for productive communication. This paper examines two of the factors that may influence the language development process for children with severe disabilities by exploring the relationship between varying degrees of symbol arbitrariness and extant speech comprehension skills in the discrimination, learning, and use of symbols for communication.

Factors that affect symbol learning

To aid our understanding of the language acquisition process of children who acquire their skills through AAC modes, consideration of the multiple factors that affect their learning is needed. The contribution of both intrinsic and extrinsic

CONTACT Rose A. Sevcik rsevcik@gsu.edu Georgia State University, Department of Psychology, P.O. Box 5010, Atlanta, GA, 30302-5010

factors to the process of augmented language learning (Romski & Sevcik, 1996; Romski, Sevcik, & Adamson, 1997) must be considered. Intrinsic factors are those that the child brings to the augmented language-learning task and include biological foundations (e.g., neurological status) and psychological competencies (e.g., cognitive and language skills). Extrinsic factors are those that comprise or affect the language-learning environment including the instructional approach and the symbols employed.

Intrinsic factors

One essential intrinsic factor that must be considered is the receptive language skill that individuals bring to the augmented language-learning task (Sevcik, 2006). In a study of children who were developing typically, Namy, Campbell, and Tomasello (2004) found that younger children (13–18 months), with less developed comprehension, were able to learn both arbitrary and iconic sets of gestures equally well. The older children in their study (26 months), who had more developed sets of vocabulary in comprehension, were able to learn iconic gestures but not arbitrary gestures for the vocabulary items. Iconicity did not give the younger children an advantage. There appears to be interplay between comprehension skill and symbol arbitrariness that affects symbol learning. Children with less developed comprehension may not use iconicity to learn a symbol-referent relationship. Their symbolic repertoire is more malleable and in the process of developing or emerging. As children's symbolic repertoire develops (i.e., language), it appears they take advantage of this growing comprehension knowledge to more readily learn iconic rather than arbitrary symbols.

In a longitudinal study of 13 youths with severe cognitive and spoken language disabilities, two distinct patterns of achievement emerged and were attributed to the spoken language comprehension skills or lack thereof that they brought to the augmented language learning task (Romski & Sevcik, 1996; Sevcik & Romski, 1997). The first achievers acquired symbols in comprehension and then production because they came to the task with a less developed speech comprehension foundation than the advanced achievers. They had to learn to comprehend the symbols before they began to produce them. Because these youths learned only arbitrary symbols, it is not known what effect extant comprehension skills may have on learning non-arbitrary guessable symbols.

Barton, Sevcik, and Romski (2006) explored iconic versus arbitrary visual-graphic symbol learning in four pre-school aged children with developmental delays and limited speech ability. Highly translucent Blissymbols (Archer, 1977) and arbitrary lexigrams (Rumbaugh, 1977) were used to teach the participants vocabulary that they did not yet comprehend. No differences were found in their ability to learn iconic versus arbitrary symbols, but the participants' extant comprehension skills, as assessed by a standardized comprehension measure, appeared to influence their performance in the number of symbols learned overall.

Extrinsic factors

One extrinsic factor that may influence symbol learning is the symbol set used to teach the meanings of the words. The iconicity of the symbols and their interaction with extant comprehension skills may be a key extrinsic factor that contributes to variations in children's ability to readily learn symbol-referent relationships. Iconicity is a feature of a symbol that varies across symbol sets and refers to a symbol's degree of arbitrariness (i.e., the degree to which a symbol does or does not physically resemble its referent or meaning). Sevcik, Romski, and Wilkinson (1991) advanced the perspective that the symbols themselves play dual roles in this process of acquisition because they are both the external medium and the vehicle by which communication is achieved, and the internalized representations of real world experiences of the person (Bruner, 1968; Werner & Kaplan, 1963). Stephenson (2009) further described the role of iconicity by arguing that it is in the eye of the beholder and thus influenced by the cognitive resources an individual brings to the symbol-learning task. DeLoache (1995; 2004) suggested that, in order for a child to perceive an object as a symbol, he or she must distinguish the symbol's physical features as separate from its symbolic function. She defined a symbol as "something that someone intends to represent something other than itself" (DeLoache, 2004, p. 66).

Scholars and practitioners alike have argued that the use of arbitrary symbols with children with disabilities may impede a child's ability to learn the meanings of symbols efficiently because they do not provide any representational cues about the meaning of the symbols (Beukelman & Mirenda, 2013). The majority of research on symbol sets has focused on how children with typical development and adults without disabilities perceive symbols and/or learn the association between symbols and spoken words (Mizuko, 1987; Sevcik et al., 1991; Worah, McNaughton, Light, & Benedek-Wood, 2015). Results from these studies show that symbol learning is affected by the level of symbol iconicity or arbitrariness (i.e., concrete versus abstract) and a symbol's physical configuration (e.g., complexity, shape; Ecklund & Reichle, 1987; Mizuko, 1987; Musselwhite & Russello, 1984).

To date, few studies have directly explored symbol iconicity as a key extrinsic component of symbol learning in children with developmental disabilities (Angermeier, Schlosser, Luiselli, Harrington, & Carter, 2008; Barton, Sevcik, & Romski, 2006; Emms & Gardner, 2010). Emms and Gardner found that 14 children with cerebral palsy more readily learned iconic symbols versus less iconic symbols; however, an interaction effect was found between symbol iconicity and instruction type. Children more readily learned opaque (i.e., less iconic) symbols when taught via direct instruction methods versus a contextual interaction during storybook reading. Angermeier et al. found that iconicity was not an important factor in symbol learning when using the Picture Exchange Communication System (PECS; Frost & Bondy, 1994) protocol. In the study, four children with autism spectrum disorder between 6 and 9 years of age were taught to match Picture

Communication Symbols[1] and Blissymbols (Bliss, 1978) with their corresponding object referent using the + PECS protocol. All participants achieved mastery with both symbol sets, suggesting that there was no benefit to symbols that looked more like their referent. Using a verbal task, Mirenda and Locke (1989) found a hierarchy of symbol representation for objects to Blissymbols and written words for non-speaking children and adolescents with a range of cognitive disabilities. With the exception of Emms and Gardner, these studies did not address the integration of extant speech comprehension skills or lack thereof when learning iconic or arbitrary symbols. Emms and Gardner found that age as opposed to language ability was a significant factor in symbol learning. In addition, there are no empirical reports on the impact of iconicity on the use of a symbol for expressive communication.

Namy (2008) suggested that iconicity is not a key component in a child's ability to learn symbol referent relationships within the first year of life. During the period that children are developing symbolic relationships, iconicity of the symbol to its referent does not drive symbolic learning. Instead, contextual factors, such as referential cues and the co-occurrence of the symbol and referent, are key for learning that the symbol has a 'stands-for relationship' to its referent. Using novel spoken words and novel sounds, Campbell and Namy (2003) provided evidence that children with typical development between 13 and 18 months of age used their experience along with information about the context of the symbol production in relation to its referent, rather than the iconicity of the symbol to its referent, in order to learn symbol referent relationships. In further empirical evidence, first and advanced achievers with severe intellectual disabilities have been shown to learn, use, and retain arbitrary symbols (lexigrams for nouns, verbs, and social-regulative words) for communication (Adamson, Romski, Deffebach, & Sevcik, 1992; Romski & Sevcik, 1992, 1996; Romski, Sevcik, & Pate, 1988). Since the arbitrary symbol bears no iconic relationship to the referent, it may simplify the task for children with disabilities. When accounting for the child's extant comprehension, this direct comparison of symbol iconicity may provide information that will disentangle the intrinsic and extrinsic components of symbol learning that address a central issue in initial symbol acquisition (Sevcik et al., 1991).

The purpose of the current study was to further examine the relationship between symbol acquisition and the nature of the symbol set employed, taking into account the speech comprehension skills the participants brought to the experimental task. Specifically, we explored the learning of arbitrary lexigram-referent relationships versus comparatively more iconic Blissymbol-referent relationships by 13 school-aged children who had both developmental and language delays. A computerized program and display was used with participants. Each participant had an interactive experience seeing a specific set of lexigram- and Blissymbol-referent pairs. Five questions were asked: (1) What are the children's representational matching skills? (2) Do children discriminate different symbol sets with the same ease? (3) Do children learn symbol-referent relationships equally well regardless of the iconicity of the symbol set employed? (4) Does extant comprehension skill affect children's learning of symbol-referent relationships? 5) Are symbols generalized to a new communicative setting?

Method

Participants

This research was conducted with Institutional Review Board approval at Georgia State University. The participants were 13 children (six male and seven female) between 4 and 11 years of age ($M_{CA} = 8.24$ years) with both developmental and language delays. They were recruited from the special education program at a school system in a major city in the southeastern United States. Each child received an Individualized Education Plan (IEP) that provided appropriate and individualized special education (e.g., modified curricula) and related services (e.g., speech-language therapy). All participants could visually cross the midline to view the entire array of symbols, could match identical objects to photographs, and passed hearing and visual acuity screenings within the year prior to the start of the study. With the exception of S6 and S10, all were ambulatory. Their educational placements ranged from classes for students with moderate to severe intellectual disabilities. They represented heterogeneous etiologies and a range of receptive and expressive communication abilities. All received speech and language services as part of their educational program; none was using an augmentative and alternative communication (AAC) device or had been exposed to graphic symbol sets prior to this study.

Table 1 describes each participant's age, diagnosis, and performance on the Peabody Picture Vocabulary Test-III (PPVT-III; Dunn & Dunn, 1997) and the classroom edition of the Vineland Adaptive Behavior Scales (Sparrow, Balla, & Cicchetti, 1984). Only three of the 13 achieved a basal score on the PPVT-III; therefore, raw scores and age equivalent scores, where applicable, were reported for all participants. The mean PPVT-III raw score was 15.62 ($SD = 16.71$, range: 4–52). The mean score for the Vineland scales was 57.3 ($SD = 10.63$, range: 34–72). The participants' mean receptive and expressive language age equivalent scores as assessed by the Vineland were 40.46 months ($SD = 38.13$; range: 14–144) and 26.69 months ($SD = 15.62$; range: <12–65), respectively.

Materials

Symbol sets. Two symbol sets – Blissymbols (Bliss, 1978) and lexigrams (Rumbaugh, 1977) – were used. The sets provided experience with arbitrary and iconic symbols, while ensuring that the participants had no prior knowledge of either set. Hetzroni, Quist, and Lloyd (2002) rated Blissymbols on a translucency rating scale. They found that Blissymbols with a translucency rating of 3.5 and above were highly

[1]Picture Communication Symbols is a product of Mayer-Johnson (part of the Tobi Dynavox Family), Pittsburgh, PA. www.mayer-johnson.com/pages/pcs-symbol-collections.

Table 1. Participant descriptive information.

#	Gender	CA	Diagnosis	Educ. placement level	PPVT-III (AE; raw score)	Vineland Adap.Beh. (SS)	Vineland Com.Domain (SS)	Vineland RL AE	Vineland EL AE
S1	M	11;08*	ASD	M IDD	no basal; 9	42	25	1;2*	1;4*
S2	M	10;04	IDD	S IDD	no basal; 5	51	39	1;5	1;2
S3	F	8;10	IDD	M IDD	4;01*; 52	72	73	12;0	3;11
S4	F	10;04	DS	M IDD	4;03; 46	62	56	3;1	2;7
S5	F	8;0	DS	M IDD	no basal; 7	55	51	1;11	1;7
S6	M	11;05	CP (quadraplegia)	S IDD	no basal; 5	34	32	3;1	1;5
S7	M	10;08	ASD	M IDD	no basal; 10	54	63	8;4	5;5
S8	F	4;09	DD	Sig. DD	2;09; 34	65	71	2;1	1;10
S9	F	6;03	DS	M IDD	no basal; 7	61	63	1;11	1;8
S10	M	7;0	CP	M IDD	no basal; 10	62	70	3;1	3;6
S11	F	6;05	DS	M IDD	no basal; 4	62	64	2;6	1;9
S12	M	6;08	DS	M IDD	no basal; 6	55	55	1;2	Below 1;0
S13	F	4;09	DS	Sig. DD	no basal; 8	70	69	2;1	1;10

Note. CA: chronological Age; ASD: autism spectrum disorder; CP: cerebral palsy; DS: Down syndrome; IDD: intellectual and developmental disability; DD: developmental disability; M: moderate; S: severe; sig: significant; AE: age equivalent; SS: standard score, PPVT-III: Peabody Picture Vocabulary Test, III; Vineland: Vineland Adaptive Behavior Scales, Com. Domain: communication domain, RL: receptive language, EL: expressive language; * years/months.

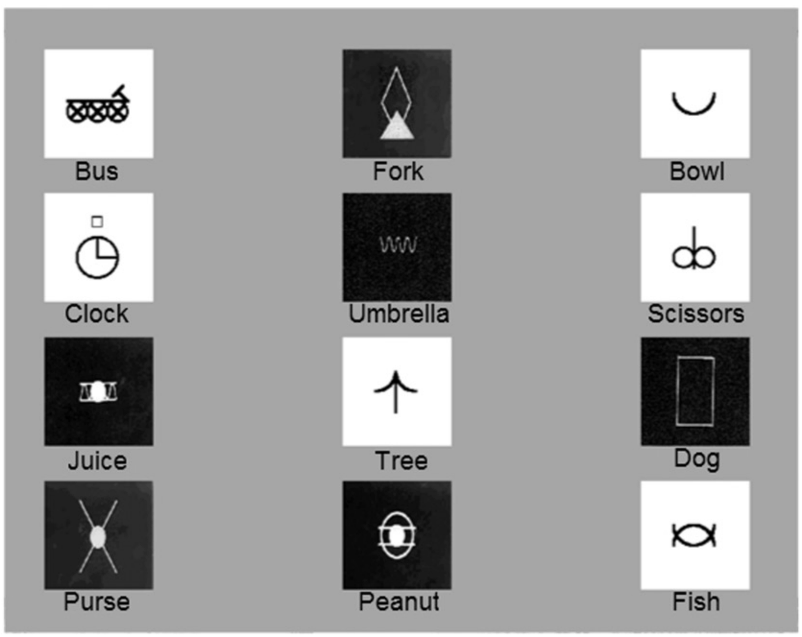

Figure 1. Blissymbol and lexigram vocabulary display. Note that printed words did not appear with the symbols during the experiment, but are used here to illustrate the vocabulary concepts represented by each symbol.

guessable. Only Blissymbols with a translucency rating of 4.0 or above were used in this study, thus all Blissymbols used were iconic to adults without disabilities. They were presented in black on a white background. Lexigrams are an arbitrary symbol system that can be composed of one, two, three, or four basic elements from a pool of nine geometric forms, with one being the least and four being the most complex. Lexigrams are randomly assigned meaning and appear as white on a black background. There is no iconic relationship between a lexigram and its referent.

Six lexigrams and six Blissymbols were chosen to represent each participant's vocabulary. The lexigram for each vocabulary item was equally paired in terms of visual complexity (1, 2, 3, or 4 elements) with each Blissymbol. Figure 1 provides an example of a 3 × 4 array of Blissymbols and lexigrams used in this study. The printed word was provided for the reader to know the target vocabulary referent; however, this printed word was not present for the participant to see during the study.

Vocabulary. There were 12 noun vocabulary items randomly assigned to be represented by either a Blissymbol or lexigram. Six were paired with their corresponding Blissymbol, and six were assigned to a lexigram. Out of the six Blissymbols and six lexigrams, three vocabulary items that were chosen were comprehended by the participants and three others were not. The vocabulary sets for each participant were concrete nouns that could be depicted through color photographs (e.g., bus, umbrella, finger). Initially, the vocabulary was selected from established word lists created from work done with typically developing preschool-age children (e.g., Beukelman, Jones, & Rowan, 1989; Fried-Oken & More, 1992; Rescorla, Alley, & Christine, 2001; Thorndike, 1932; Wepman & Hass, 1969). In order to accommodate the advanced comprehension skills shown by some of the participants, higher level, but still age appropriate, words that were not on the lists were chosen, to ensure that there were vocabulary items that the participants did not comprehend. Comprehension of the words was assessed by presenting participants with an array of four photographs and asking them to *Show me* _____. Each word was presented four times in a randomized order. If the participant demonstrated 75% or greater accuracy in identifying the photograph, the word was considered comprehended.

Procedure

There were three phases in the study: preliminary assessment, observational symbol experience, and generalization.

Phase 1: Preliminary skill assessment. Two types of preliminary tasks were given before the participants received computer experience with the new vocabulary and symbols. The first task assessed their representational matching skills, and the second task assessed their ability to discriminate Blissymbols and lexigrams in a visual identity matching task. These two tasks provided information about the participants' skills.

Representational assessment. This task, developed by Sevcik and Romski (1986), assessed the participants' ability to match objects to objects, objects to photographs, objects to line drawings, and photographs to line drawings. One set of four trials was administered for each of the four levels of representation. The objects used were a toy telephone, book, toy car, and crayon. Each object, photograph, or line drawing was tested once for each condition. The participant was given either the object or the photograph and instructed to *Find this one* from an array of three of the other objects, photographs, or line drawings placed in one of three bins in front of him or her. No feedback as to the correctness of the response was offered, though general praise was given for completing the trial. Four trials were administered in each condition for a total of 16 trials.

Lexigram and Blissymbol discrimination. Once the participant's symbol vocabulary was selected, his or her ability to perceptually discriminate the six Blissymbols and six lexigrams was assessed. Four symbols were placed in front of the participant, who was then asked to place the target symbol presented by the investigator with its exact identity match. Lexigrams were matched to lexigram foils and Blissymbols were matched to Blissymbol foils. No feedback as to the correctness of the response was offered, though the participant was given general praise for completing the trial. Four trials per symbol were administered for a total of 24 trials for each symbol set. This task provided experimental control permitting us to distinguish visual perceptual demands from the demands of symbol meaning.

Phase 2: Computer-based observational symbol experience. Participants were seen individually in an unoccupied classroom in the school building for approximately 30 min a session. The investigators, along with speech-language pathology undergraduate students, administered the tasks. Phase 2 of the study provided each participant with the observational experience of seeing the six Blissymbols and six lexigrams individually paired with their referents, and participants were then assessed on their acquisition of the 12 symbol meanings. The 12 vocabulary items represented with symbols were displayed in a 3×4 array on a color IBM flat screen monitor overlaid with a touch-sensitive screen (see Figure 1). The monitor was connected to a laptop computer system that ran a software program specifically designed for the study (Sevcik & Fonseca, 2000). The software program captured each participant's symbol activations and produced a summary printout at the end of each session. The computer-based symbol experience permitted the juxtaposition of both symbols and photographs in a highly efficient and standardized manner.

In order to activate a symbol, the participant directly touched the symbol on the screen. When touched, the participant simultaneously saw a full-screen color photograph of its corresponding vocabulary referent displayed on the screen and heard the name of the referent via digitized speech. After the photograph was displayed for a 3-s period, the screen returned to the original 3×4 array of Blissymbols and lexigrams and the array of 12 symbols randomly relocated. The participant could then touch another symbol on the screen to view its corresponding vocabulary referent. If the participant did not touch another symbol, the investigator encouraged the participant to do so. The investigator kept track of the symbols activated to ensure that all 12 were sampled during the session. Each session targeted at least eight experiences per symbol, or a total minimum of at least 96 overall symbol experiences per session. The average number of overall experiences per symbol for participants was nine and the average number of symbol experiences per session overall was 109. Computer sessions were administered once per day for a maximum number of 12 sessions, regardless of the participant's progress in comprehending the symbol sets. If the participant demonstrated 100% comprehension of all 12 symbol meanings prior to session 12, their participation was completed for the phase.

Assessing comprehension and production. Comprehension and production of the symbol meanings was assessed after three, six, nine, and 12 computer sessions. Comprehension was measured by asking the participant to match the symbol to the target $3'' \times 5''$ (7.6×12.7 cm) photograph displayed in an array of four photographs arranged in a line. The photograph was identical to the image previously seen on the computer screen. The symbol was presented to the participant printed on a $3'' \times 5''$ (7.6×12.7 cm) index card. Four trials per symbol were administered using randomly assigned foils of photographs from the participants' vocabulary set. These tasks followed the assessment protocols of the longitudinal study by Romski and Sevcik (1996). Comprehension of the symbol was recorded if the participant correctly identified the photograph in three out of four trials. Emerging comprehension of the symbol was documented if the participant correctly identified the photograph in two out of four trials.

The participant's production skill was assessed next, using a similar method. This time the participants were given a $3'' \times 5''$ (7.6×12.7 cm) photograph and were told to choose the correct $3'' \times 5''$ (7.6×12.7 cm) index card with the symbol printed on it from an array of four to indicate what the target photograph represented. Again, production of the symbol was recorded if the participant correctly produced the symbol in three out of four trials and emerging production of the symbol was documented if the participant correctly produced the symbol in two out of four trials.

Phase 3: Generalization activity. An essential component of symbol learning is its use in a communicative environment. In this phase, each participant played an interactive board game with the investigator to assess generalization of the 12 symbols with which they had experience. The board game consisted of the photographic referents in individual squares on the path from start to finish. The Blissymbols and lexigrams were attached with Velcro to a separate board with an arrow for spinning in the center. The investigator and participant took turns spinning the board to choose a symbol. After taking a turn spinning the board, the participant moved his or her game piece to the referent photograph deemed a match with the Blissymbol or lexigram. When the investigator took a turn spinning, she asked the participant to move her game piece for her to the correct photograph. Playing the game in this manner allowed the participants to continue to label the photographs independently and not gain cues from the investigator. The game was modified for S2, S4, and S10. For S2, the investigator modeled the appropriate action of moving the game piece to the photograph throughout the course of the game because the participant did not seem to understand the rules of the game. S4 and S10 did not understand how to use the game piece to label the photographs, so they were allowed to remove the symbols from the spinning board and use them in place of the game piece to label the photograph of their choice. The investigator did not model the appropriate placement of the symbol on the game board. The participant and investigator continued the game until the participant had an opportunity to use all 12 symbols on the spinning board and each had reached the finish line. The participants' responses were recorded and tallied by the investigator.

Results

Phase 1

Representational assessment. Table 2 describes the participants' performance on the representational task. Of the 13, six were able to complete all four representational tasks with 100% accuracy; eight were able to match objects to objects with 100% accuracy; four were able to match objects with 75% accuracy, and one was able to match objects with 25% accuracy. Twelve participants were able to match objects to photographs with 100% accuracy and one was able to achieve 75% accuracy. Eleven participants were able to match objects to line drawings with 100% accuracy and two with 75% accuracy; 11 also were able to match photographs to line drawings with 100% accuracy. One participant achieved 50% accuracy and one achieved 25% accuracy.

Lexigram and Blissymbol discrimination. Table 3 reports the performance of each participant on the Blissymbol and lexigram discrimination task. Both Blissymbols and lexigrams had a mean discrimination score above 90% accuracy. Five participants – S1, S3, S4, S7, and S8 – each discriminated lexigrams and Blissymbols with 100% accuracy. All of the others were able to discriminate between lexigrams and Blissymbols above 75% accuracy.

Phase 2

Symbol experience. Table 4 provides a detailed summary of each participant's average number of experiences per symbol, range of experiences per symbol, and total number of sessions with the computer. With the exception of S1, S2, and S3, all participants completed 12 sessions with the computer. S1 and S3 only needed nine sessions of computer experience to learn all symbols in comprehension and production, while S2 needed only six sessions of computer experience to learn all symbols in comprehension and

Table 3. Participant performance on lexigram and blissymbol discrimination tasks.

Participant	Lexigrams	Blissymbols
S1	1.00	1.00
S2	0.75	1.00
S3	1.00	1.00
S4	1.00	1.00
S5	0.95	0.91
S6	0.91	0.91
S7	1.00	1.00
S8	1.00	1.00
S9	1.00	0.95
S10	0.95	0.87
S11	1.00	0.95
S12	0.87	1.00
S13	0.95	0.91

Note. Scores represent proportion correct out of four trials.

Table 2. Participant performance on four representational tasks.

Participant	Object to object	Object to photograph	Object to line drawing	Photograph to line drawing
S1	1.00	1.00	0.75	1.00
S2	1.00	1.00	1.00	1.00
S3	1.00	1.00	1.00	1.00
S4	1.00	1.00	1.00	1.00
S5	0.75	1.00	1.00	1.00
S6	1.00	1.00	0.75	1.00
S7	1.00	1.00	1.00	1.00
S8	0.75	1.00	1.00	1.00
S9	1.00	1.00	1.00	1.00
S10	1.00	1.00	1.00	1.00
S11	0.75	1.00	1.00	0.50
S12	0.75	0.75	1.00	0.25
S13	0.25	1.00	1.00	1.00

Note. Scores represent proportion correct out of four trials.

Table 4. Computer experience.

Participant	Average number of experience per symbol	Range of experience per symbol	Total number of sessions*
S1	91.0	80-119	9
S2	57.6	50-71	6
S3	80.5	76-86	9
S4	109.9	103-125	12
S5	128.0	106-172	12
S6	121.9	102-177	12
S7	112.0	99-145	12
S8	118.0	105-175	12
S9	122.0	110-147	12
S10	126.9	102-283	12
S11	113.8	100-162	12
S12	114.4	104-126	12
S13	118.9	108-132	12

Note. *Participants S1, S2, and S6 learned all 12 symbols in comprehension and production when assessed after noted sessions, therefore they did not continue to 12 sessions.

Table 5. Symbols emerging or learned in comprehension and production.

	Comprehension				Production			
	Blissymbols		Lexigrams		Blissymbols		Lexigrams	
Participant	Known	Unknown	Known	Unknown	Known	Unknown	Known	Unknown
S1	3L	3L	3L	3L	3L	3L	3L	3L
S2	3L	3L	3L	3L	3L	3L	3L	3L
S3	3L	3L	3L	3L	3L	3L	3L	3L
S4	3L	3L	3L	3L	3L	3L	3L	3L
S5	3L	3L	3L	3L	3L	3L	3L	3L
S6	3L	3L	3L	1E, 2L	3L	3L	3L	1E, 2L
S7	1E, 2L	1E, 2L	1L	3L	1E, 2L	2E, 1L	2L	3L
S8	1E, 1L	2E, 2L	2E, 1L	1E, 2L	3E	2E, 1L	3L	2E
S9	2E, 1L	3L	2E, 1L	1L	2E	3E	2L	1E
S10	2L	2L	2E, 1L	1E, 1L	3L	3E	1E, 1L	2E
S11	3L	2L	1L	1E	1E, 1L	2E,1L	1E, 1L	1E, 2L
S12	3L	1L	1E, 1L	2E, 1L	2E, 1L	1E	2E	3E
S13	2L	1E	1E	2E	1E, 2L	3E	3E	2E, 1L

Note. E: emerging (a score in assessment from 0.50 to 0.74); L: learned (a score in assessment of 0.75 or greater).

Table 6. Blissymbol and lexigram acquisition across all six vocabulary items and three vocabulary items not understood prior to symbol experience.

	Blissymbols				Lexigrams
Vocabulary	Mean (*SD*)	*t*	*d*	CI	Mean (*SD*)
Comprehended	4.77 (1.36)	2.793*	0.773	[0.21986, 1.78014]	3.77 (2.20)
Produced	3.69 (2.36)	−0.433	−0.120	[−0.92796, 0.62027]	3.85 (2.27)
Unknown comprehended	2.31 (.95)	1.594	−0.442	[−0.14095, 0.91018]	1.92 (1.19)
Unknown Produced	1.62 (1.39)	−0.693	−0.192	[−0.63767, 0.32998]	1.77 (1.36)

Note. CI: confidence interval; Unknown: number of symbols learned out of three possible vocabulary items that were not understood.
*$p < .05$.

production. Overall, the participants had an average of 109 experiences per symbol ($SD = 20$, range: 50–283).

Acquisition of symbols. A symbol was operationally defined as learned if the participant's score in assessment was 0.75 or greater, and defined as emerging if it was between 0.50 and 0.75. Chance level performance was 0.25. Table 5 provides the individual number of symbols learned and emerging in comprehension and production for prior known vocabulary and unknown vocabulary items. In comprehension and production, all participants evidenced knowledge of symbol-referent relationships, and five (S1, S2, S3, S4, and S5) demonstrated comprehension and production of all six Blissymbols and six lexigrams. Paired-sample *t*-tests were run to test for significant differences in number of Blissymbols versus lexigrams learned in comprehension and production. A *t*-test was determined to be appropriate because these tests are robust to violations of normality without affecting the validity of the hypothesis test (Gravetter & Wallnau, 2002). The differences between Blissymbols and lexigrams learned in comprehension were not normally distributed as assessed by Shapiro-Wilk test ($p = .003$). The differences between Blissymbols and lexigrams learned in production were normally distributed as assessed by Shapiro-Wilk test ($p = .126$). As shown in Table 6, participants on average learned more Blissymbols in comprehension ($M = 4.77$, $SD = 1.36$) than lexigrams ($M = 3.77$, $SD = 2.20$); a statistically significant mean difference of 1.00, 95% CI [0.21986, 1.78014], $t(12) = 2.793$, $p = .016$, $d = 0.773$, two-tailed. Participants did not show a mean difference in the number of Blissymbols learned in production ($M = 3.69$, $SD = 2.36$) versus lexigrams ($M = 3.85$; $SD = 2.27$); 95% CI [−0.92796, 0.62027], $t(12) = -0.433$, $p = 0.673$, two-tailed.

When looking specifically at vocabulary that was not understood prior to the participant's symbol experience,

Table 7. PPVT-III, vineland receptive and expressive language scores and symbol comprehension and production.

				Comprehension		Production	
Participant	PPVT-III (AE; raw score)	Vineland RL (AE; raw score)	Vineland EL (AE; raw score)	Blissymbols	Lexigrams	Blissymbols	Lexigrams
S1	No basal; 9	1:02; 9	1:04; 9	6L	6L	6L	6L
S2	No basal; 5	1:05; 11	1:02; 7	6L	6L	6L	6L
S3	4:01; 52	12:00; 20	3:11; 41	6L	6L	6L	6L
S4	4:03; 46	3:01; 17	2:07; 30	6L	6L	6L	6L
S5	No basal; 7	1:11; 14	1:07; 14	6L	6L	6L	6L
S6	No basal; 5	3:01; 17	1:05; 10	6L	1E, 5L	6L	1E, 5L
S7	No basal; 10	8:04; 19	5:05; 48	2E, 4L	4L	3E, 3L	5L
S8	2:09; 34	2:01; 15	1:10; 18	2E, 3L	3E, 3L	5E, 1L	2E, 3L
S9	No basal; 7	1:01; 14	1:08; 15	2E, 4L	2E, 2L	5E	1E, 2L
S10	No basal; 10	3:01; 17	3:06; 38	4L	3E, 2L	3E, 3L	3E, 1L
S11	No basal; 4	2:06; 16	1:09; 17	5L	1E, 1L	3E, 2L	2E, 3L
S12	No basal; 6	1:02; 9	below 1:0; 4	4L	3E, 2L	3E, 1L	5E
S13	No basal; 8	2:01; 15	1:10; 18	1E, 2L	3E	4E, 2L	5E, 1L

Note. E: emerging (a score in assessment from 0.50 to 0.74); L: learned (a score in assessment of 0.75 or greater).

Table 8. Summary of intercorrelations, means, and standard deviations for receptive and expressive language and number of blissymbols and lexigrams learned in comprehension or production.

Measure	1	2	3	4	5	6	7
1. Vineland RL	–						
2. Vineland EL	.850**	–					
3. PPVT-III	.479	.721	–				
4. Blissymbols comprehended	.033	-.264	-.094	–			
5. lexigrams comprehended	.026	-.094	.294	.832**	–		
6. Blissymbols produced	.215	-.020	.130	.867**	.832**	–	
7. lexigrams produced	.118	.009	.212	.841**	.922**	.843**	–
M	14.85	20.69	15.62	4.77	3.77	3.69	3.85
SD	3.46	14.04	16.71	1.36	2.20	2.36	2.27

Note. Vineland: Vineland Scales of Adaptive behavior; RL: Receptive Language Subtest; EL: Expressive Language Subtest; PPVT: Peabody Picture Vocabulary Test-III. Raw scores were used in all calculations.
$^{**}p < .01$.

there were no significant differences in the number of Blissymbols ($M = 2.31$, $SD = 0.95$) versus lexigrams ($M = 1.92$, $SD = 1.19$) learned in comprehension, 95% CI [–.14095, .91018], $t(12) = 1.594$, $p = .137$. There also were no significant differences in the number of Blissymbols ($M = 1.62$, $SD = 1.39$) versus lexigrams ($M = 1.77$, $SD = 1.36$) learned in production, 95% CI [–.63767, .32998], $t(12) = –.693$, $p = .502$.

Standardized test performance compared to symbol acquisition. Table 7 compares the performance of each participant on the PPVT-III and receptive and expressive communication subscales of the Vineland scales to the number of symbols either emerging or learned in comprehension and production. Two participants, S3 and S4, obtained age equivalent scores above those of a 4-year-old on the PPVT-III and learned all six Blissymbols and lexigrams. Three other participants, S1, S2 and S5, who learned all six Blissymbols and lexigrams, did not obtain a basal score on the PPVT-III and had some of the lowest raw scores in receptive and expressive language on the Vineland. A Spearman rank-order correlation assessed the relationship between the participants' receptive and expressive language ability and number of Blissymbols and lexigrams learned in comprehension or production, as shown in Table 8. No significant correlations were found.

Phase 3

Generalization. Table 9 presents participants' performance in the generalization game. All participants were able to engage with the examiner during the game. Because S12 and S6 did not understand how to use a game piece to label each photograph and move it across the board, they were allowed to remove the symbol from the spinning board and place it directly on the photograph as they played. All other participants used a separate game piece to label the photographs. The average number of Blissymbol referents correctly identified while playing the game was 3.23 ($SD = 2.31$), and the average number of lexigram referents correctly identified was 2.3 ($SD = 1.70$). S4 was the only participant to correctly identify all Blissymbol and lexigram referents.

Discussion

Participants' performance on the representational matching task did not yield evidence of a fixed hierarchy of difficulty that has been reported in the literature (Mirenda & Locke, 1989). This finding calls into question how 'fixed' a representational hierarchy may be for children with these profiles and supports the notion that symbol representation as an extrinsic factor interacts with individuals' intrinsic factors, namely, language comprehension and production.

The participants distinguished Blissymbols and lexigrams, suggesting that any subsequent learning difficulty was not based on a lack of symbol discrimination ability. All evidenced at least emergent comprehension of four of 12 symbols when given experience with their symbol referent pairs via the computer program. Of the 13, five (38%) learned all 12 symbol vocabulary items in comprehension and production, while seven more (54%) of the 13 learned at least six of the 12 symbols in comprehension. One participant evidenced

Table 9. Generalization game results.

Participant	Item used for identification	Number of Blissymbol referents correctly identified		Number of lexigram referents correctly identified	
		U	K	U	K
S1	Game piece	2	2	1	3
S2	Game piece	2	1	2	2
S3	Game piece	3	3	1	1
S4	Game piece	3	3	3	3
S5	Game piece	3	3	2	1
S6	Physical symbols	3	3	1	2
S7	Game piece	2	2	0	1
S8	Game piece	0	0	1	0
S9	Game piece	2	1	1	2
S10	Game piece	0	2	0	0
S11	Game piece	1	0	0	1
S12	Physical symbols	0	1	0	1
S13	Game piece	0	0	0	1

Note. U: unknown; K: known.

emergent comprehension of at least four symbols. These findings suggest that, regardless of the iconicity of the symbol, participants were able to establish iconic and arbitrary symbol-referent relationships when given experience with them. They add to the findings of Angermeier et al. (2008) and Namy (2008) that iconicity may not be an important factor for symbol learning by children with autism spectrum disorder or children with typical development, respectively, by including children with developmental disabilities.

There was a modest difference in ability to learn arbitrary versus iconic symbols. On average the participants learned one more Blissymbol than lexigram if the vocabulary item was understood prior to the symbol experience. As Sevcik (2006) described, comprehension is an important contributor to learning symbol meanings. If the vocabulary item was unknown prior to the symbol learning experience, however, there was no difference in the ability to learn an iconic Blissymbol versus an arbitrary lexigram as its referent. These findings suggest that simply because a symbol looks more like its referent, it does not mean that it will be more rapidly learned by an individual who does not yet have the target referent in comprehension.

This study provides evidence that children with developmental disabilities and significant delays in receptive and expressive language are able to learn new symbol-referent relationships via a computer-based experience. Some participants were able to learn the relationships of prior known vocabulary items more readily than others. Overall, however, extant comprehension of vocabulary did not significantly limit their ability to learn symbols. Given the chance, some of the students with the lowest standard scores in receptive and expressive language and communication were able to learn all 12 iconic and arbitrary symbol-referent relationships taught to them.

Limitations and future directions

There are a few limitations that must be considered. First, the current study had a modest sample size, and student profiles were varied in terms of age, educational placement level, adapted behavior, and comprehension skills. Secondly, the vocabulary taught was confined to nouns, thus generalization of these findings to other word classes is limited. Thirdly, results of the generalization game should be interpreted with caution. Given the participants' limited receptive language skills, many had a difficult time comprehending the instructions for the game. Finally, it is not known if they would have learned more with a larger dosage of intervention and/or greater intensity of experience, or if another instructional strategy would have produced different results.

Future studies should explore in greater detail the ability of students to generalize their learning of symbol referent relationships to functional communication contexts. Examining the transfer of learning of specific symbol referent relationships to use in production on an AAC device for functional communication may be an important next step. A limited symbol vocabulary is often a barrier to communicative development. Ways in which vocabulary can be more readily and quickly acquired would address this often identified issue. The role of an observational computer-linked task, followed by context-based naturalistic instruction, should be explored to determine if this sequential experience could jumpstart a learner's ability to use vocabulary on an AAC device productively.

Conclusion

This study expands evidence about the interaction between intrinsic and extrinsic factors in symbol learning for children with developmental disabilities. Findings suggest that iconicity of a symbol may not be a critical factor in learning a symbol-referent relationship for a child who does not yet have the target referent in comprehension. Using a computer-linked system to teach symbol meanings may offer another approach for establishing and/or expanding vocabulary for use in subsequent communication interactions.

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