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RESEARCH ARTICLE

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

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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

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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.

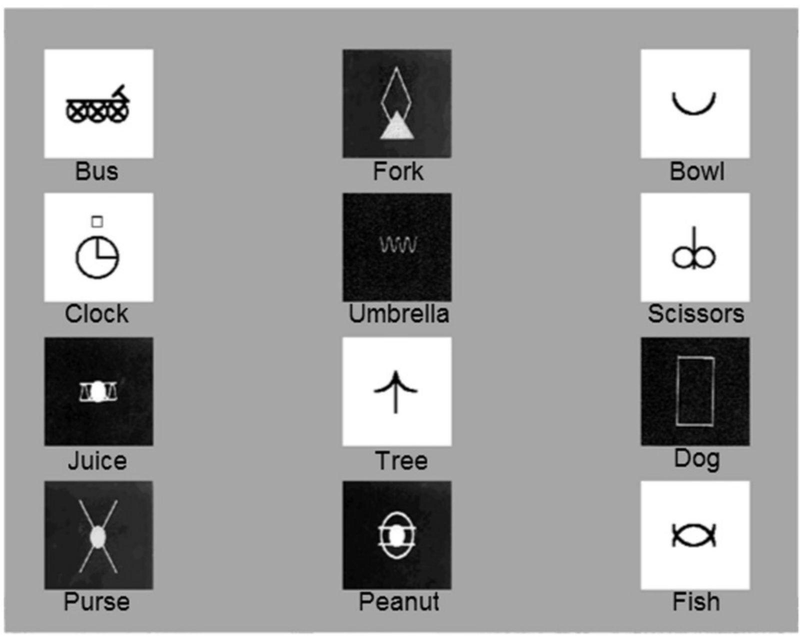

Figure 1. Blissymbol and lexigram vocabulary display. Note that printed words did not appear with the symbols during the experiment, but are used here to illustrate the vocabulary concepts represented by each symbol.

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″ × 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″ × 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″ × 5″ (7.6 × 12.7 cm) photograph and were told to choose the correct 3″ × 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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References

Abbeduto, L., McDuffie, A., Thurman, A.J., & Kover, S.T. (2016). Language development for individuals with intellectual and developmental disabilities: From phenotypes to treatments. *International Review of Research in Developmental Disabilities*, *50*, 71–118. doi:10.1016/bs.irrdd.2016.05.006

Adamson, L.B. (1996). *Communication development in infancy*. Madison, WI: Brown and Benchmark.

Adamson, L.B., Romski, M.A., Deffebach, K., & Sevcik, R.A. (1992). Symbol vocabulary and the focus of conversations: Augmenting language development for youth with mental retardation. *Journal of Speech and Hearing Research*, *35*, 1333–1343. doi:10.1044/jshr.3506.1333

Angermeier, K., Schlosser, R.W., Luiselli, J.K., Harrington, C., & Carter, B. (2008). Effects of iconicity on requesting with the Picture Exchange Communication System in children with autism spectrum disorder. *Research in Autism Spectrum Disorders*, *2*, 430–446. doi:10.1016/j.rasd.2007.09.004

Archer, L.A. (1977). Blissymbolics: A a nonverbal communication system. *Journal of Speech and Hearing Disorders*, *42*, 568–579. doi:10.1044/jshd.4204.568

Barrett, M.D., & Diniz, F.A. (1989). Lexical development in mentally-handicapped children. In M. Beveridge, G. Conti-Ramsden, & L. Leudar (Eds.), *Language and communication in mentally handicapped people* (pp. 3–32). London: Chapman & Hall.

Barton, A., Sevcik, R.A., & Romski, M.A. (2006). Exploring visual-graphic symbol acquisition by pre-school age children with developmental and language delays. *Augmentative and Alternative Communication*, *22*, 10–20. doi:10.1080/07434610500238206

Bates, E., With Benigni, L., Bretherton, I., Camaioni, L., & Volterra, V. (1979). *The emergence of symbols: Cognition and communication in infancy*. New York: Academic Press.

Benedict, H. (1979). Early lexical development: Comprehension and production. *Journal of Child Language*, *6*, 183–201. doi:10.1017/S0305000900002245

Beukelman, D.R., Jones, R.S., & Rowan, M. (1989). Frequency of word usage by nondisabled peers in integrated preschool classrooms. *Augmentative and Alternative Communication*, *5*, 243–248. doi:10.1080/07434618912331275296

Beukelman, D.R., & Mirenda, P. (2013). *Augmentative and alternative communication management of severe communication disorders in children and adults* (4th ed). Baltimore, MD: Paul H. Brookes.

Bliss, C. (1978). *Semantography (Blissymbolics)*. Sydney, Australia: Semantography Publications.

Bonvillian, J.D., & Nelson, K.E. (1982). Exceptional cases of language acquisition. In K.E. Nelson (Ed.), *Child language* (*Vol. 3*, pp. 322–389). Hillsdale, N.J.: Erlbaum Associates.

Bruner, J. (1968). On cognitive growth. In J. Bruner, & P.M. Greenfield (Eds.), *Studies in cognitive growth* (pp. 1–29). New York: John Wiley.

Bruner, J. (1983). *Child's talk: Learning to use language*. New York: Norton.

Burack, J.A., Russo, N., Green, C.G., Landry, O., & Iarocci, G. (2016). Developments in the developmental approach to intellectual disability. In D. Cicchetti (Ed.), *Developmental Psychopathology: Maladaptation and Psychopathology* (pp.1–67). Hoboken, NJ: John Wiley and Sons.

Campbell, A., & Namy, L.L. (2003). The role of social-referential context in verbal and nonverbal symbol learning. *Child Development*, *74*, 549–563. doi:10.1111/1467-8624.7402015

DeLoache, J.S. (1995). Early symbol understanding and use. In D. Medin (Ed.), *The psychology of learning and motivation* (Vol. 33, pp. 65 –114). New York: Academic Press.

DeLoache, J.S. (2004). Becoming symbol-minded. *Trends in Cognitive Sciences*, *8*, 66–70. doi:10.1016/j.tics.2003.12.004

Dunn, L.M., & Dunn, L.M. (1997). *Peabody Picture Vocabulary Test* (3rd ed., PPVT-III). Circle Pines, MN: American Guidance Services.

Ecklund, S., & Reichle, J. (1987). A comparison of normal children's ability to recall symbols from two logographic systems. *Language, Speech and Hearing Services in Schools*, *18*, 34–40. doi:10.1044/0161-1461.1801.34

Emms, L., & Gardner, H. (2010). Study of two graphic symbol-teaching methods for individuals with physical disabilities and additional learning difficulties. *Child Language Teaching and Therapy*, *26*, 5–22. doi:10.1177/0265659009339820

Fried-Oken, M., & More, L. (1992). An initial vocabulary for non-speaking preschool children based on developmental and environmental language sources. *Augmentative and Alternative Communication*, *8*, 41–56. doi:10.1080/07434619212331276033

Frost, L.A., & Bondy, A.S. (1994). *The Picture Exchange Communication System training manual*. Cherry Hill, NJ: Pyramid Educational Consultants.

Gravetter, F.J., & Wallnau, L.B. (2002). *Essentials of statistics for the behavioral sciences* (4thed.). Pacific Grove, CA: Wadsworth.

Hetzroni, O.E., Quist, R.W., & Lloyd, L.L. (2002). Translucency and complexity: Effects on Blissymbol learning using computer and teacher presentations. *Language, Speech, and Hearing Services in Schools*, *33*, 291–303. doi:10.1044/0161-1461(2002/024)

Mirenda, P., & Locke, P. (1989). A comparison of symbol transparency in nonspeaking persons with intellectual disability. *Journal of Speech and Hearing Disorders*, *54*, 131–140. doi:10.1044/jshd.5402.131

Mizuko, M. (1987). Transparency and ease of learning symbols represented by Blissymbols, PCS and Picsyms. *Augmentative and Alternative Communication*, *3*, 129–136. doi:10.1080/07434618712331274409

Musselwhite, C., & Ruscello, D. (1984). Transparency of three symbol communication systems. *Journal of Speech and Hearing Research*, *27*, 436–443. doi:10.1044/jshr.2703.436

Namy, L.L. (2008). Recognition of iconicity doesn't come for free. *Developmental Science*, *11*, 841–846. doi:10.1111/j.1467-7687.2008.00732.x

Namy, L.L., Campbell, A.L., & Tomasello, M. (2004). The changing role of iconicity on non verbal symbol learning: A U-shaped trajectory toward the acquisition of arbitrary gestures. *Journal of Cognition and Development*, *5*, 37–57. doi:10.1207/s15327647jcd0501_3

Nelson, K. (1985). *Making sense: The acquisition of shared meaning*. New York: Academic Press.

Rescorla, L., Alley, A., & Christine, J. (2001). Word frequencies of toddlers' lexicons. *Journal of Speech, Language, and Hearing Research*, *44*, 598–609. doi:10.1044/1092-4388(2001/049)

Romski, M.A., & Sevcik, R.A. (1988). Augmentative and alternative communication systems: Considerations for individuals with severe intellectual disabilities. *Augmentative and Alternative Communication*, *4*, 83–93. doi:10.1080/07434618812331274667

Romski, M.A., & Sevcik, R.A. (1992). Developing augmented language in children with severe mental retardation. In S.F. Warren & J. Reichle (Eds.), *Causes and effects in communication and language intervention* (pp. 113–130). Baltimore: Paul H. Brookes Publishing.

Romski, M.A., & Sevcik, R.A. (1996). *Breaking the speech barrier: Language development through augmented means*. Baltimore, MD: Paul H. Brookes.

Romski, M.A., Sevcik, R.A., & Adamson, L.B. (1997, March). Toddlers with developmental disabilities who are not speaking: Family stress, home environment, and language intervention. In N. Brady (Chair), *Communication Disorders and Families*. Symposium conducted at the 30th annual Gatlinburg Conference on Research and Theory in Mental Retardation and Developmental Disabilities. Riverside, CA.

Romski, M.A., Sevcik, R.A., & Pate, J.L. (1988). The establishment of symbolic communication in a person with severe retardation. *Journal of Speech and Hearing Disorders*, *53*, 94–107. doi:10.1044/jshd.5301.94

Rumbaugh, D.M. (1977). *Language learning by a chimpanzee: The Lana Project*. New York: Academic Press.

Sevcik, R.A. (2006). Comprehension: an overlooked component in augmented language development. *Disability and Rehabilitation*, *28*, 159–167. doi:10.1080/09638280500077804

Sevcik, R.A., & Fonseca, M. (2000). Symbol program [Computer Software].

Sevcik, R., & Romski, M.A. (1986). Representational matching skills of persons with severe retardation. *Augmentative and Alternative Communication*, *2*, 160–164. doi:10.1080/07434618612331273980

Sevcik, R.A., & Romski, M.A. (1997). Comprehension and language acquisition: Evidence from youth with severe cognitive disabilities. In L. B. Adamson & M. A. Romski (Eds.), *Communication and language acquisition: Discoveries from atypical development* (pp. 184–201). Baltimore, MD: Paul H. Brookes.

Sevcik, R.A., & Romski, M.A. (2016). *Communication interventions for individuals with severe disabilities: Exploring research challenges and opportunities*. Baltimore, MD: Paul H. Brookes.

Sevcik, R., Romski, M.A., & Wilkinson, K. (1991). Roles of graphic symbols in the language acquisition process for persons with severe cognitive disabilities. *Augmentative and Alternative Communication*, *7*, 161–170. doi:10.1080/07434619112331275873

Schlosser, R.W., & Sigafoos, J. (2002). Selecting graphic symbols for an initial request lexicon: Integrative review. *Augmentative and Alternative Communication*, *18*, 102–123. doi:10.1080/07434610212331281201

Snyder, L., Bates, E., & Bretherton, I. (1981). Content and context in early lexical development. *Journal of Child Language*, *8*, 565–582. doi:10.1017/S0305000900003433

Sparrow, S., Balla, D., & Cicchetti, D. (1984). *Vineland Adaptive Behavior Scales*. Circle Pines, MN: American Guidance Service.

Stephenson, J. (2009). Iconicity in the development of picture skills: Typical development and implications for individuals with severe intellectual disabilities. *Augmentative and Alternative Communication*, *25*, 187–201. doi:10.1080/07434610903031133

Stephenson, J., & Linfoot, K. (1996). Pictures as communication symbols for students with severe intellectual disability. *Augmentative and Alternative Communication*, *12*, 244–256. doi:10.1080/07434619612331277708

Thorndike, E.L. (1932). *The teacher's wordbook of the twenty thousand words found most frequently and widely in general reading for children and young people (Rev)*. New York: Teacher's College, Columbia University.

Wepman, J.M., & Hass, W. (1969). *A Spoken Word Count: Children 5, 6 and 7*. Chicago: Language Research Associates.

Werner, H., & Kaplan, B. (1963). *Symbol formation: An organismic developmental approach to language and the expression of thought*. New York: John Wiley.

Worah, S., McNaughton, D., Light, J., & Benedek-Wood, E. (2015). A comparison of two approaches for representing AAC vocabulary for young children. *International Journal of Speech-Language Pathology*, *17*, 460–469. doi:10.3109/17549507.2014.987817