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Research Article

Early Sentence Productions of 3- and 4-Year-Old Children Who Use Augmentative and Alternative Communication

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Purpose: This study investigated the early rule-based sentence productions of 3- and 4-year-old children with severe speech disorders who used single-meaning graphic symbols to communicate.
Method: Ten 3- and 4-year-olds requiring the use of augmentative and alternative communication, who had largely intact receptive language skills, received instruction in producing up to four different semantic–syntactic targets using an Apple iPad with a communication app. A single-case, multiple-probe, across-targets design was used to assess the progress of each participant and target. Generalization to new vocabulary was assessed, and a subgroup also was taught to produce sentences using grammatical markers.
Results: Some targets (primarily possessor-entity) were mastered in the baseline phase, and the majority of the remaining targets were mastered during intervention. All four children who completed intervention for grammatical markers quickly learned to use the markers accurately.
Conclusions: Expressive language potential for preschoolers using graphic symbol–based augmentative and alternative communication systems should not be underestimated. With appropriate presentation and intervention techniques, some preschoolers with profound speech disorders can readily learn to produce rule-based messages via graphic symbols.

Preschoolers with significant speech impairments often require augmentative and alternative communication (AAC) to meet their communication needs (Binger & Light, 2006). Some of these children have motor speech disorders, such as childhood apraxia of speech or dysarthria, whereas others have severe to profound speech sound disorders (Shriberg et al., 2010). Regardless of the nature of the speech disorder, using aided communication modes such as graphic symbols (i.e., photographs and line drawings) is essential to support language development for preliterate children. Reaching one's communication potential—including the use of productive language—is just as much of a human right for children with profound speech disorders as it is for children who rely on speech to communicate (National Joint Committee, 1992).

In typical development, language form and content develop rapidly during the preschool years, and interventions to help children who rely on aided AAC to keep pace with their peers in these aspects of language development are sorely needed. The onset of syntax for children who are typically developing is 18 months, when children begin to combine words. As a starting point, then, AAC researchers have examined the relatively simple question of whether it is even viable to expect children to combine words when using graphic symbols to communicate. For example, across four studies, Binger, Kent-Walsh, and colleagues taught a total of 21 children ages 2;11 (years;months) to 7;1 to produce graphic symbol word combinations—with credit given for *any* symbol combinations (Binger, Kent-Walsh, Berens, Del Campo, & Rivera, 2008; Binger, Kent-Walsh, Ewing, & Taylor, 2010; Binger & Light, 2007; Kent-Walsh, Binger, & Malani, 2010). The children in these studies possessed a wide range of diagnoses and profiles, but all demonstrated more than adequate expressive language potential, on the basis of receptive language scores, for producing symbol combinations. All but one of these children demonstrated gains in graphic symbol combinations following intervention.

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An emerging body of research involving both children who are typically developing and children who require AAC provides initial indications young children can be taught to produce rule-based sentences as well. First, somewhat older children (ages 7–13 years) with cognitive and receptive language impairments have been successfully taught to use graphic symbols to produce limited sets of two-symbol, rule-based messages (Nigam, Schlosser, & Lloyd, 2006; Tönsing, 2015; Tönsing, Dada, & Alant, 2014). In the Tönsing studies, for example, children with receptive language ages as low as 2;6 demonstrated improvements in their rates of two-symbol sentence productions. Second, in a recent experimentally controlled study, three children ages 4–6 years learned to consistently produce three-symbol comments and questions (e.g., "Woody is laughing"; "Is Woody laughing?"; Kent-Walsh, Binger, & Buchanan, 2015; characters are from Pixar's *Toy Story* by Arnold, Catmull, Guggenheim, Job, & Lasseter, 1995). All three children generalized use of these structures to novel sentence types ("*Woody is happy*"; "*Is Woody happy?*"), with one 4-year-old also generalizing to agent-action-object (AAO) statements and questions ("*Is Woody pushing Buzz?*"). This latter finding is particularly compelling, as it contradicts the findings of Sutton, Trudeau, Morford, Rios, and Poirier (2010, as discussed below).

To date, the profiles of children requiring AAC included in most research studies have varied widely. As an initial attempt to more narrowly define relevant populations, Binger and colleagues examined the two- and three-word rule-based graphic symbol productions of four 5-year-old children who needed AAC, all of whom demonstrated receptive language skills within normal limits (Binger, Kent-Walsh, King, Webb, & Buenviaje, 2016; King, Binger, & Kent-Walsh, 2015). All four participants unexpectedly produced a range of semantic–syntactic structures following a relatively brief dynamic assessment (DA) task, with no further direct instruction required. Another approach used to control for participant factors—an approach taken in several studies by Sutton and colleagues—has been to use children who are typically developing. In one such study, children ages 4–6 years accurately produced rule-based, two- and three-word graphic symbol sentences, such as nonreversible AAO (e.g., *BOY PUSH CAR*) following minimal instruction (Poupart, Trudeau, & Sutton, 2013). Although the 5- and 6-year-olds performed near ceiling levels without instruction, the 4-year-olds were not far behind, demonstrating accuracy levels of more than 70%. These findings are in contrast to findings from this same research group in which 3- and 4-year-olds who were typically developing did not produce *reversible* AAO sentences accurately (e.g., *BOY PUSH GIRL*; Sutton, Trudeau, Morford, Rios, & Poirier, 2010). Although multiple factors may have contributed to the different findings across these latter two studies, one likely contributor was the nature of the targets. Understanding and creating the types of reversible AAO structures used by Sutton et al. (2010) does not occur in typical language development until approximately 48 months of age (Miller & Paul, 1995), with children relying earlier in development on "probable event strategies" to determine the meaning of sentences (Paul & Norbury, 2012). For example, for passive voice sentences, such as *The cat chases the dog,* a younger child may interpret this to mean the more probable event of the dog chasing the cat. Children are able to comprehend and use structures that do not rely heavily on word order, such as *The cat drinks milk,* earlier in development (Paul & Norbury, 2012).

Taken as a whole, the research to date is promising, but further systematic investigation involving a range of targets is needed, along with investigation of intervention techniques to support learning. Also, given recent indications that 4- and 5-year-olds can produce two- and three-word messages (Kent-Walsh et al., 2015; Poupart et al., 2013), investigating whether young children also may be able to use early developing grammatical markers such as possessive *–'s* and third-person singular *–s* in graphic symbol productions may be viable as well. To address these needs, specific aims for the current investigation included the following:

1. To evaluate the effect of a multicomponent AAC intervention on the independent production of two- and three-term semantic–syntactic relations (AAO, entity-attribute, entity-locative, possessor-entity) by 3- and 4-year-old children requiring AAC.
2. To evaluate the participants' ability to independently generalize to similar targets using novel vocabulary.
3. To evaluate the effect of the same type of multicomponent AAC intervention on select participants' production of grammatical markers as an exploratory measure.

Method

General Procedures

The 10 children in the current study are the same 10 children included in this article's companion article (Binger, Kent-Walsh, & King, 2017), and they also participated in a language sampling study (Binger, Ragsdale, & Bustos, 2016). All participants were recruited through contacts at a university speech and hearing clinic and nearby public schools.

Research Design

A single-case, multiple-probe, across-targets experimental design was used to evaluate outcomes. Seven children completed four targets, and three completed three targets. Children only completed targets that they comprehended, as discussed later in this article.

Participants

Two 3-year-olds and eight 4-year-olds were included in the study and ranged in age from 3;3 to 4;11. Participants spoke English as a first language, demonstrated receptive language within normal limits, and understood the targeted semantic–syntactic relations. Although not a requirement, all children exhibited the ability to produce spoken word combinations during a language sample, with their mean length of utterances ranging from 1.2 to 2.7 words (Binger, Ragsdale, & Bustos, 2016). More detailed inclusion criteria are located in the companion article (Binger et al., 2017). Individual participant characteristics and testing information are located in Tables 1 and 2 of the companion article (Binger et al., 2017) and Supplemental Materials S1 and S2. Only Children N and H had prior AAC experience. Children O and P, the last two children enrolled in the study, were 3 years old. Two participants did not meet all inclusion criteria: Child L's receptive language scores were slightly below the cutoff, and Child H had a diagnosis of autism (which was not known at the onset of the study). Readers are referred to the companion article (Binger et al., 2017) for additional information about these two participants.

Setting and Experimenters

Sessions primarily were administered by the first, third, and fourth authors. The latter two authors were speech-language pathology graduate students who were required to meet a procedural standard prior to conducting experimental sessions and were supervised and assisted by the first author, an experienced researcher and clinician. All sessions were conducted in private rooms in a university clinic approximately twice per week for 60 min for each child. The experimenter and child were seated either on the floor or at a table for all tasks. All sessions were recorded with a Sony Handycam HD video camera recorder.

Targets, Materials, and Instrumentation

All participants used an iPad[1] with the Proloquo2Go[2] AAC application to complete study activities, with vocabulary programmed on communication displays. The order of the semantic–syntactic targets was counterbalanced across participants. Targets included reversible AAO, entity-attribute, entity-locative, and possessor-entity (see companion article, Binger et al., 2017, for examples). Participants were required to demonstrate comprehension of at least 80% accuracy on 10-item, target-specific comprehension tasks adapted from Miller and Paul (1995). Children I, L, and P did not meet this standard for locatives and therefore were not assigned this target. The remaining children completed all four targets.

Vocabulary for all study activities, with the exception of the Mickey Mouse™ characters,[3] was selected from the Communication Development Inventory–Second Edition (Fenson et al., 2007) and is listed in Supplemental Material S3. In addition, the word *is* was included as an independent symbol, represented orthographically, to allow for entity-attribute productions ("*Mickey is big*"). The grammatical markers *the, possessive –'s*, and third-person singular *–s* also were included on the displays. These markers were neither modeled nor required until the second intervention phase.

Colored line drawings from the Proloquo2Go app were used to represent all vocabulary except for the Mickey Mouse characters, with the latter consisting of photographs of plush dolls. Symbols were organized using a Fitzgerald key (McDonald & Schultz, 1973). All participants used identical communication displays. A total of six displays were used: two for tracking the dependent measure via video probes (including use of the Mickey Mouse characters), two for intervention sessions (including use of animal characters such as Cow and Lion), and two for generalization video probes (using novel vocabulary). For each pair of displays, one contained AAO and possessor-entity vocabulary, and the other contained entity-attribute and entity-locative vocabulary (see Supplemental Materials S4, S5, S6, S7, S8, and S9).

Participants completed a symbol familiarization task by matching each graphic symbol with its accompanying spoken word before completing the DA task (see companion article, Binger et al., 2017, for details). Materials used for play-based intervention sessions consisted of toy versions of the items in Supplemental Material S3, including various puppets and plastic figurines of the animal characters (e.g., Cow, Lion). Additional materials were provided as needed (e.g., a toy train for the animals).

Dependent Measures: Video Probes

A master pool of 50 probes was developed for each target. From this master pool, 10 probe lists, each containing 10 items, were created. Each vocabulary word appeared the same number of times on each probe list, and items within each list were randomly ordered. In addition to the 10 items, each probe list also contained two randomly selected foils, which consisted of single-word naming of the characters (e.g., "*Mickey*"). Brief video clips were created on an iPad to depict each item; for example, for *MINNIE CHASE PLUTO*, both characters appeared on the screen, with Minnie Mouse™ running after a squealing Pluto™. Video clips were saved and organized on the iPads using the Photo Manager Pro[4] app.

[1]The Apple iPad is a line of tablet computers designed and marketed by Apple Inc. See http://www.apple.com/ipad for more information about the Apple iPad.

[2]Proloquo2go is a product from AssistiveWare and is an AAC software application developed for iPad, iPhone, and iPod touch. See http://www.assistiveware.com/product/proloquo2go for more information.

[3]*Mickey Mouse Clubhouse* is an American animated television series that premiered on Disney Channel in 2006. See http://disneyjunior.com/mickey-mouse-clubhouse for more information.

[4]PhotoManager Pro is an iPad app by Linkus designed to assist with managing large numbers of photos and videos. See https://itunes.apple.com/us/app/photo-manager-pro/id393858562?mt=8 for more information.

Two iPads were used during each probe session: one containing the video clips, and the other containing the communication display. After viewing a clip, the examiner provided a brief prompt, such as, "Tell me about this one." If needed, the examiner provided additional general cues, such as pointing toward the iPad. Participants were permitted to replay the videos as needed. Participants were taught to use the message bar at the top of the screen to play back their completed messages. Self-corrections were permitted, with the child's final production recorded in real time by the examiner for data analysis purposes. Feedback on the correctness of the responses was not provided. Child cues, such as playing back a completed message, then reaching to start the next video, were used to indicate when a message was complete. Additional video probe details are located in King et al. (2015).

Procedure

Dynamic Assessment

After completing initial testing and the symbol familiarization task, participants completed a DA task. DA results are the focus of the companion article, where they are discussed in detail (Binger et al., 2017). In brief, participants completed a 10-trial DA task for each target, with each trial consisting of a series of graduated prompts designed to elicit the targets.

Baseline Phase

Baseline sessions were completed for each target to establish current levels of performance on the dependent measures. Data were collected using the probe procedures discussed in the "Dependent Measures: Video Probes" section. For any given target (e.g., AAO), the participant completed one set of 10 items (plus two foils) per target; the percentage correct for each set was then calculated for each target. To be counted as correct, the participant had to produce all vocabulary in a given sentence using correct word order; for example, for "*Mickey drop Goofy,*" all three symbols had to be present in this exact order. Participants completed one set of items for as many targets as possible (e.g., AAO followed by entity-locative) within each 60-min session. After one set of targets was completed, the cycle began again in the same order. Stable baselines were defined as a minimum of three sessions with a maximum variability of 20% and no ascending trend (Kratochwill et al., 2010; see Supplemental Material S10 for additional procedural information).

Main Intervention Phase

The three tasks completed, in order, during each intervention session included (a) video probes, (b) concentrated modeling, and (c) play. Video probes were used to track progress on the dependent measure. If a target was undergoing intervention, progress on that target was assessed using video probes at the onset of the following session. Concentrated modeling and play focused on intervention for one particular target. During concentrated modeling, the examiner provided a series of 10 pairs of contrastive models designed to highlight key features of the target (Courtright & Courtright, 1979). The nature of the contrast changed, depending on the target: (a) reversals for AAO ("*Pig kiss Cow*" vs. "*Cow kiss Pig*"); (b) opposites for entity-attribute ("*Pig is wet*" vs. "*Pig is dry*"); (c) prepositions for entity-locative ("*Pig in car*" vs. "*Pig under car*"); and (d) entities for possessor-entity ("*Cow cup*" vs. "*Cow plate*"). Five different balanced, randomized lists containing 10 trials each were created for each target. To complete this task, the examiner provided a grammatically complete spoken model of the target (*Look, Pig kisses Cow*) while carrying out the accompanying action, then provided an aided model on the iPad ("*Pig kiss Cow*"). The experimenter then provided the contrast (*Now, Cow kisses Pig*, "*Cow kiss Pig*"). Participants were discouraged from producing the targets during concentrated modeling.

Next, a 20-min play session took place. Key components included setting up opportunities for communication, ensuring access to the correct communication display on the iPad, providing spoken and aided models of the target using a range of exemplars, providing ample time for communication, gesturing toward the device, providing indirect and direct spoken prompts, assisting with message productions, and providing contingent spoken and aided models following child productions. Spoken and aided expansions, extensions, imitations, and requests for clarification were used. A minimum of 10 correct aided productions of the target were produced during each session. Because both aided input (produced by the examiner) and output (produced by the child) have been shown to be important for improving aided productions (Romski, Sevcik, Adamson, Smith, & Barker, 2010), correct messages could be created by either the examiner or the child, depending on the child's needs. For example, if child productions were largely incorrect, the examiner provided numerous aided models and recasts, but if child productions were largely accurate, the examiner could provide a spoken affirmation without having to imitate an aided production. Activities were arranged to facilitate target productions. For example, for entity-locative, the examiner could make Cow hide her eyes, place Penguin under the trash can, and then ask the child to tell Cow where Penguin was ("*Penguin under trash*"). Intervention continued until the child either demonstrated at least 80% accuracy across three consecutive sessions or completed 10 intervention sessions, whichever occurred first.

Generalization Phase

Video probes of the target structures using novel vocabulary were completed for this phase (see vocabulary in Supplemental Material S3). One set of generalization probes was completed for each child and target toward the end of the baseline phase, and one set was completed following mastery of each target.

Intervention for Grammatical Markers

A subset of participants completed an additional grammatical marker intervention phase. Grammatical markers included the following: (a) third-person singular *–s* for AAO

("*Goofy* + *kiss* + *s* + *Pluto*"); (b) *is* and *the* for entity-locative ("*Goofy* + *is* + *in* + *the* + *house*"); and (c) possessive –*'s* for possessor-entity ("*Goofy* + *'s* + *plate*"). No additional markers were used for the entity-attribute target. Each grammatical marker was represented orthographically as its own individual symbol. Children who mastered targets relatively easily and whose families were willing to participate in additional sessions were included in this phase. Instructional play sessions mirrored the approach from the first intervention phase; concentrated modeling was not included in this phase.

Maintenance Phase

Three sets of maintenance probes were collected for each target approximately two, four, and eight weeks after mastery of the last target. For children completing intervention for grammatical markers, maintenance data were collected after completion of this second intervention phase. Video probes were used to collect maintenance data and mirrored baseline procedures.

Data Collection

All primary measures were based on data collected live by the examiners during video probe sessions. The percentage of correct productions for each set of 10 items was calculated for each target. Errors on foils also were noted. During baseline, no models were provided during video probe sessions. During the remaining phases, the examiner provided two aided models at the beginning of each session to prevent confusion and remind the child of what had been targeted in the previous section. Vocabulary for the models was selected randomly, no visual supports (such as video clips) were provided, and participants did not imitate these productions.

Treatment Fidelity

Fidelity measures were completed for both video probe sessions and intervention sessions to ensure accurate implementation of study procedures. Undergraduate Speech and Hearing Sciences majors who were not otherwise involved in the study and were masked to the study purposes and procedures served as coders. All coding was completed by viewing randomly ordered videotaped sessions. Accurate implementation of the video probes included playing the correct video, providing the correct prompt, refraining from providing prompts such as spoken or aided models, and refraining from indicating the correctness of the child's response. For intervention sessions, accurate implementation included providing 10 contrastive aided models followed by completion of the following during play sessions: providing access to the iPad with the correct communication display, making relevant materials available, providing at least 10 opportunities for target production, completing at least 10 correct productions of the target (by either the instructor or child), and responding contingently to the majority of the child's productions. Detailed data were collected to support the latter three measures. Fidelity measures were calculated for 26%–36% of the video probe sessions for each child, with mean fidelity scores ranging from 88%–99%. Intervention fidelity scores were calculated for 20%–56% of the sessions per child, with mean fidelity scores ranging from 93%–100%, indicating consistent administration of procedures. Across all sessions examined, a mean of 18 correct productions of the targets were produced within each play session: 47% by the examiner (augmented input) and 53% by the child (augmented output).

Data Analysis

Data were graphed and visually inspected for changes in the trend, slope, and level of the data. Also, improvement rate differences (IRDs) were calculated (Parker, Vannest, & Brown, 2009) to determine effect sizes between the baseline versus intervention phases, and also the baseline versus maintenance phases. IRD has better discriminability than the more commonly used percentage of nonoverlapping data (Parker et al.).

Data Reliability

Undergraduate Speech and Hearing Science majors masked to the purposes and procedures of the study viewed the same randomly ordered video probe sessions that were viewed for treatment fidelity to evaluate data reliability. Cohen's κ scores ranged from .82–1.0, indicating almost perfect data reliability.

Results

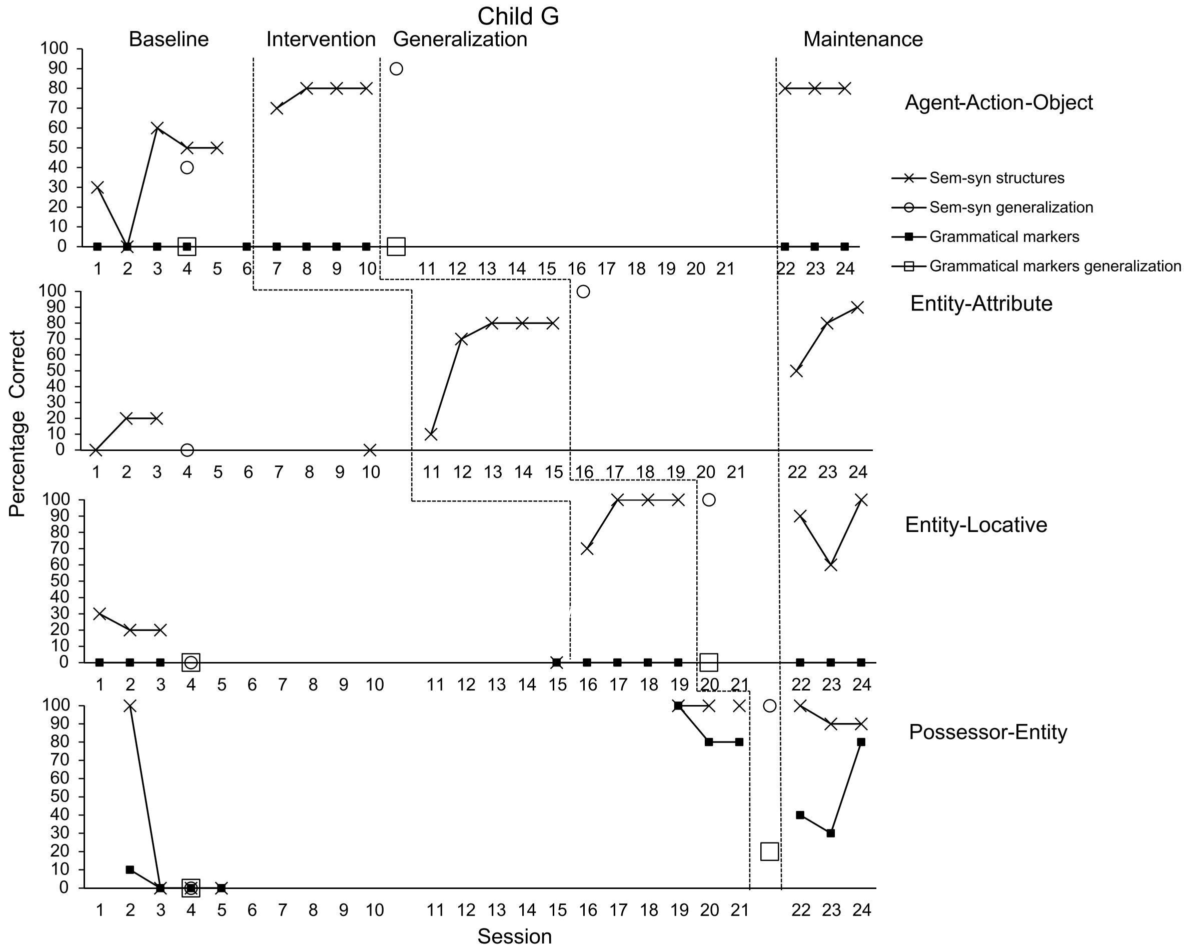
All participants completed the baseline, main intervention, generalization, and maintenance phases of the investigation. Four participants completed intervention for grammatical markers. All children demonstrated perfect or near perfect accuracy with the foils in all study phases. Experimental control—that is, at least three demonstrations of the intervention effect—was maintained for only five of the 10 participants. Therefore, the results are presented in two sections: Part 1 for experimentally controlled cases (Figures 1, 2, 7, 9, and 10), and Part 2 for cases without controls (Figures 3, 4, 5, 6, and 8).

Part 1: Experimentally Controlled Cases

Baseline

Children G, H, M, O, and P demonstrated stable baselines for three targets—that is, no more than 20% variability across three consecutive sessions with no evidence of increasing trend. However, all but Child P mastered the possessor target during baseline. In addition, although baseline stability was achieved for three targets for these five children, some success was apparent on additional targets: Child G for AAO (50%–60% accuracy), Child M for locatives (50%–60% accuracy), and Child P for possessors (all at 30%).

Figure 1. Results for Child G. Sem-syn = semantic–syntactic.



Main Intervention

An online IRD calculator was used to calculate effect sizes (Vannest, Parker, & Gonen, 2011). Large to very large effect sizes were evidenced for all targets with stable baselines (three targets for each of these five participants), with a range of .80–1.0. Effect sizes for each target and child are in Supplemental Material S11. Visual analysis revealed that Children G, H, and M all achieved mastery (at least 80% accuracy across three sessions) of their intervention targets in a maximum of five sessions. These three children mastered the same three targets during intervention: AAO, entity-attribute, and entity-locative. Patterns for the two 3-year-olds, O and P, were somewhat different: Child O quickly mastered locatives and attributes (five and four sessions, respectively) but didn't reach 80% accuracy for AAO until Sessions 9 and 10. Child P, the youngest child in the study, was the only child to not master possessors in baseline and took six sessions to reach mastery in intervention. She demonstrated gains for attributes and AAO during intervention but did not master either target after 10 intervention sessions.

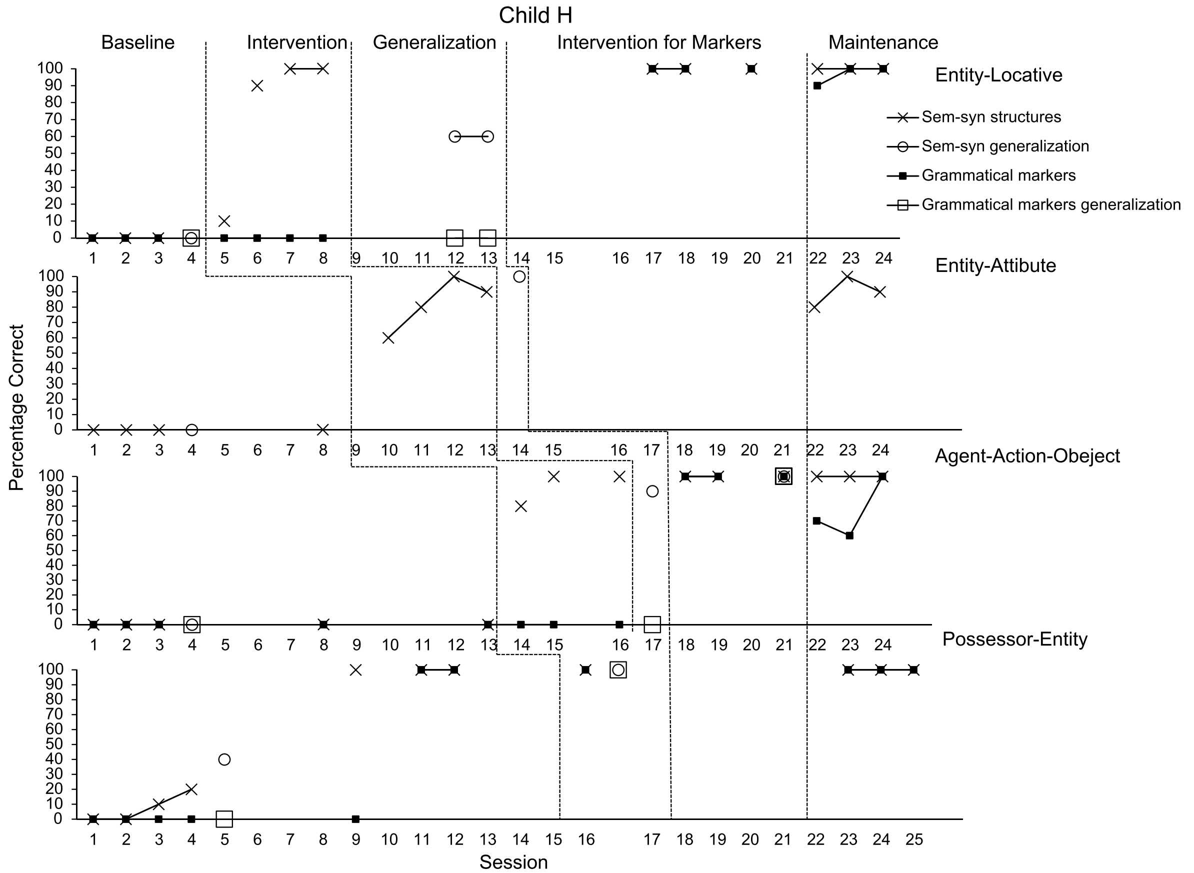
Generalization

Children G, H, and M all demonstrated significant gains during generalization, achieving at least 80% accuracy on every target with the exception of locatives for Child H (two probes at 60%). In contrast, Child O demonstrated limited to no generalization for three of four targets (all except entity-attribute), and Child P demonstrated moderate accuracy for the possessor generalization probe, with little to no generalization for AAO and attributes.

Maintenance

IRD was calculated to compare the baseline and maintenance phases (see Supplemental Material S11). Children G, H, and M attained perfect IRD scores (1.0) for experimentally controlled targets. Children O and P had perfect IRD scores for two targets, and moderate effects for entity-attribute. Visual inspection revealed high maintenance levels for all targets for Children G, H, and M, with more variable levels for Children O and P.

Figure 2. Results for Child H. Sem-syn = semantic–syntactic.



Part 2: Loss of Experimental Control

Patterns of Performance

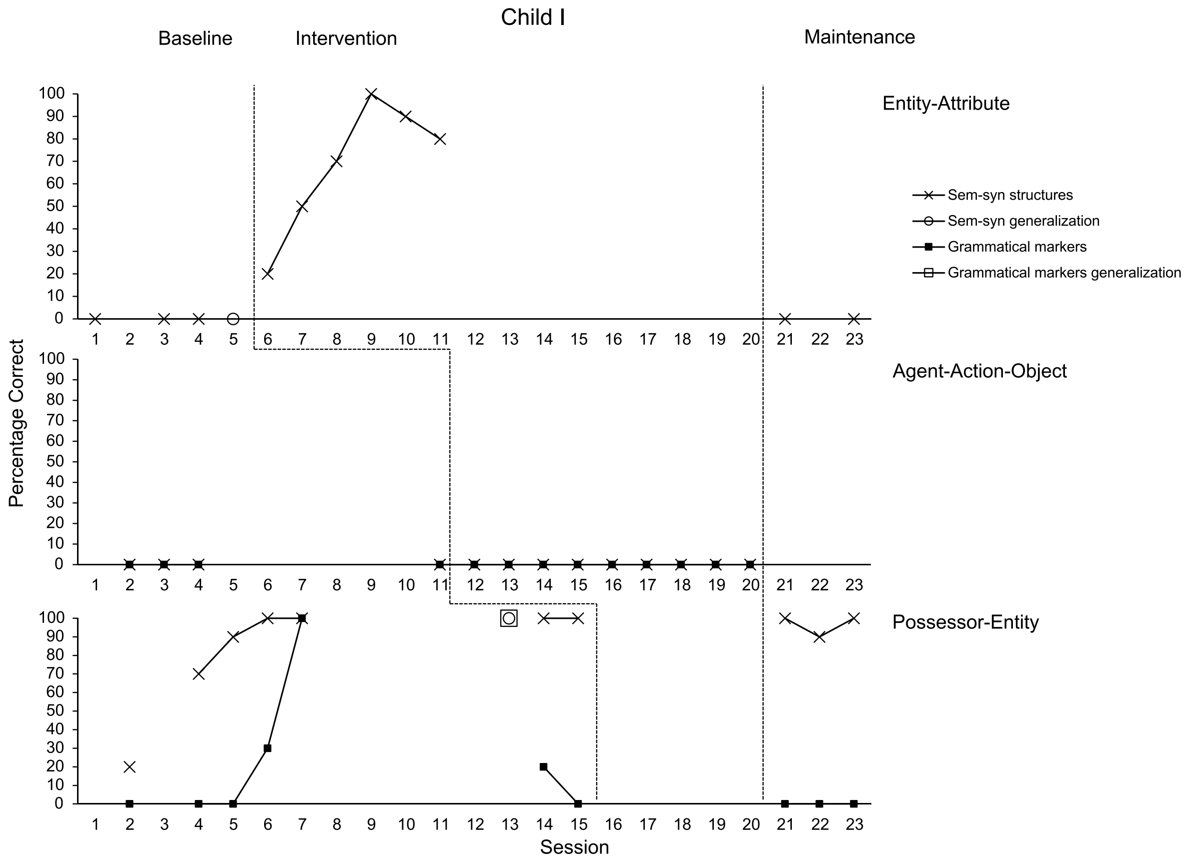
Experimental control was not maintained for Children I, J, K, L, and N. Three children—J, L, and N—simply performed too well too quickly: Child L mastered one of three targets during baseline, Child J mastered all four targets, and Child N mastered three of four targets. These three children went on to master whatever targets remained during intervention and demonstrated high maintenance and generalization levels, with the exception of challenges with AAO for Child J. He took longer to master this target, failed to generalize to new AAO vocabulary, and demonstrated variable maintenance levels (0%–50%).

The loss of experimental control was more complex for Children I and K, who each mastered one target during baseline (possessor-entity) but demonstrated no progress on AAO during intervention. This target was abandoned for both children prior to the 10th intervention session due to increases in challenging behaviors. Child I did master entity-attribute (in intervention) and possessor-entity (in baseline), but he only maintained use of the possessors; no generalization measures were collected for this participant. Child K also demonstrated mastery of his remaining targets, with strong generalization and maintenance performances.

Examination of AAO Errors

Four of the 10 children—I, K, O, and P—did not master AAO; the only other target not mastered was entity-attribute for Child P. Given the high failure rates for this target, AAO errors for these four children were analyzed further. Children I and K demonstrated similar patterns in both baseline and intervention: They typically selected all three correct symbols, but the two characters were first (agents or objects in no particular order), followed by the action (e.g., "*Mickey Pluto drop*" for "*Pluto drop Mickey*"). Child O's performance changed over time: In the first two baseline sessions, he selected only the characters in no particular order, then used all three correct symbols in no particular order for several sessions, and finally selected all three symbols in the correct order for most productions. Child P first produced single-symbol actions ("*chase*"), then an inconsistent range of one to three symbols, then consistently produced three symbols in which agents and objects were reversed, with occasional

Figure 3. Results for Child I. Sem-syn = semantic–syntactic.



selections of the wrong character or action ("*Mickey chase Pluto*" for "*Pluto drop Mickey*"). In summary, error patterns for this target were inconsistent for the participants who failed to master AAO.

Intervention for Grammatical Markers

Use of the grammatical markers *is* and *the* for locatives ("*Donald is on the house*"), third-person singular *–s* for AAO ("*Donald drop + s Goofy*"), and possessive *–'s* for possessor-entity ("*Donald + 's hotdog*") was tracked throughout the study for all 10 participants. These markers were always available during video probes and intervention, but they were neither modeled nor targeted until the intervention for grammatical markers phase. Despite this, nine participants (all except Child L) used the possessive marker accurately at least once without intervention, with four using this marker consistently: Children G, H, J, and M all used this marker toward the end of baseline. In addition, Child O demonstrated emerging use of the third-person singular *–s* during maintenance for AAO.

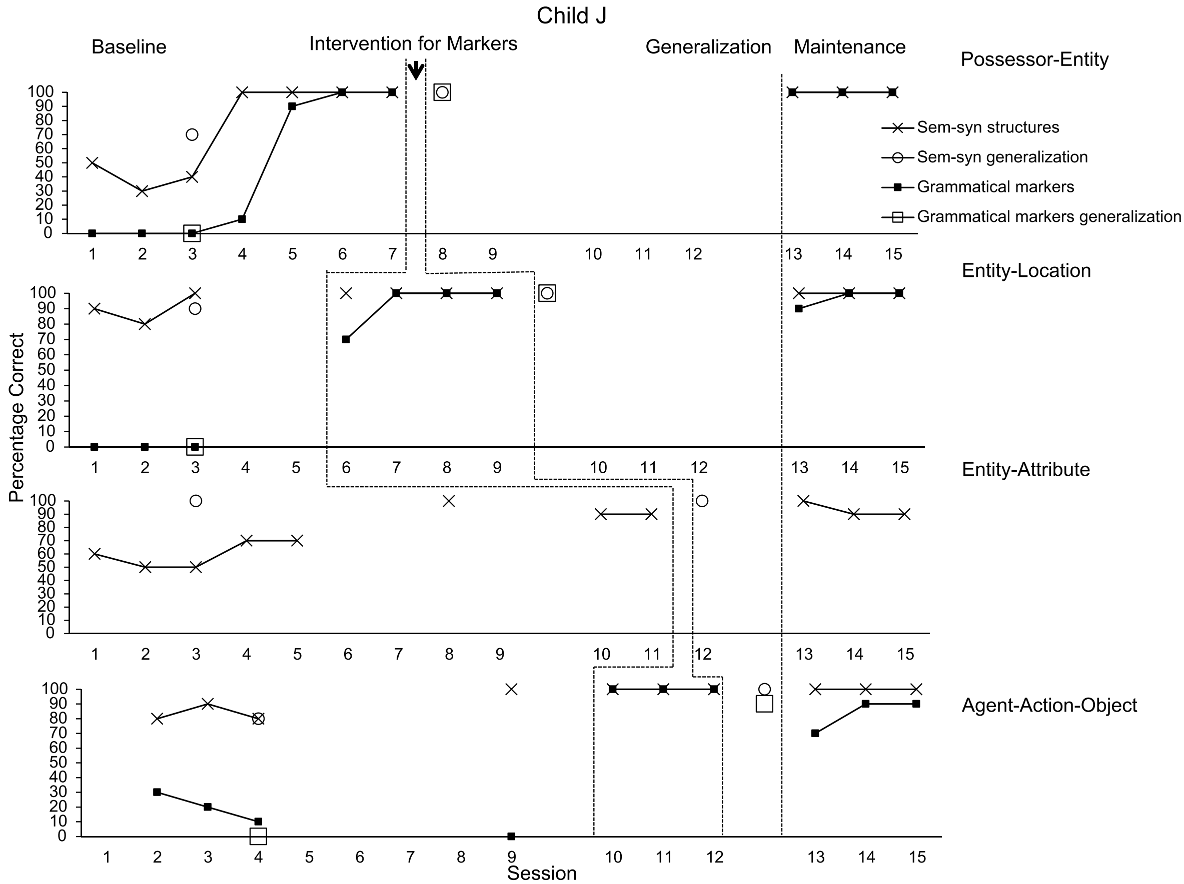
Four participants were taught to use the markers: Children H, J, and M received intervention for locatives and AAO, and Child K for locatives and possessives. All four participants demonstrated consistent use of targeted markers within one to two intervention sessions.

Discussion

Production of Semantic–Syntactic Relations (Aim 1)

The most important finding of this study is the fact that the majority of the participants mastered the majority of the targets and did so quickly. The importance of providing young children with viable modes of expressive language cannot be overstated; given prior indications that preschoolers may encounter difficulties creating graphic symbol sentences (e.g., Sutton et al., 2010), these findings are of material importance. Not only did the children in the present study learn to produce the targeted sentences, they did so in many cases without needing the planned intervention. That is, experimental control was only maintained for five of the 10 participants, largely due to mastery of the targets during the baseline sessions. Two important questions arising from the findings, then, are as follows: (a) Did the planned intervention approach in the current study contribute to the children's success? (b) Why did

Figure 4. Results for Child J. Sem-syn = semantic–syntactic.



these 3- and 4-year-old participants learn to produce rule-based graphic symbol messages, when past research has shown this to be challenging?

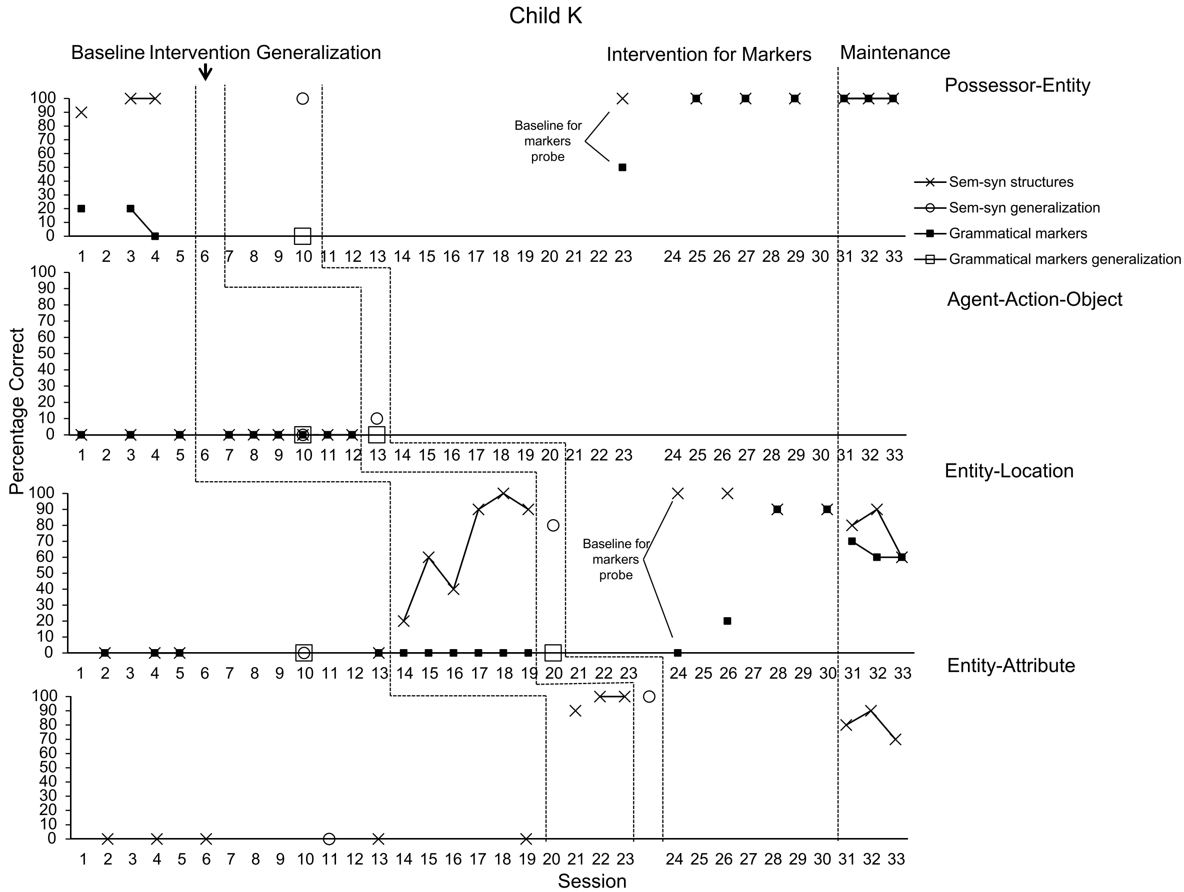
Effectiveness of the Intervention

In multiple-probe, across-targets designs, if the goal is to increase a behavior, experimental control is demonstrated by showing a positive change on the first dependent variable (DV) while holding subsequent DV targets at low baseline levels. Typically, a minimum of three demonstrations of changes to the DV that can be attributed to the intervention is required (Kratochwill et al., 2010). In the current study, three demonstrations were achieved for five of the 10 participants—Children G, H, M, O, and P. For the remaining participants, this standard was not met either due to mastery of targets during baseline (Children J, L, and N) or a combination of mastery during baseline on some targets but no progress during intervention on other targets (Children I and K). For the five cases with three clear demonstrations of change, large to very large effect sizes were demonstrated; that is, the intervention appeared to be responsible for improvements with the DV. These findings build on a body of work (e.g., Binger et al., 2008, 2010; Binger & Light, 2007; Kent-Walsh et al., 2015) demonstrating that interventions including components such as the following can be used to successfully and rapidly teach children to produce multisymbol messages: (a) using single-meaning graphic symbols; (b) providing access to all required vocabulary on one communication display, which bypasses the need for navigation; (c) encouraging the child's productions of the target; and (d) using aided models of the target. In the current study, the latter two items were defined as producing a minimum of 10 correct target productions during each play session, which could consist of either augmented input or output (Romski et al., 2010). Overall, approximately half of the aided sentences in the current study consisted of augmented input and half consisted of augmented output. Taken as a whole, these findings contribute to a growing body of evidence indicating that these intervention components can help teach young children to begin producing a range of multisymbol messages.

Ease of Acquisition and Differences Across Targets

Experimental control was not maintained for five of 10 participants, largely due to mastery of targets in the

Figure 5. Results for Child K. Sem-syn = semantic–syntactic.

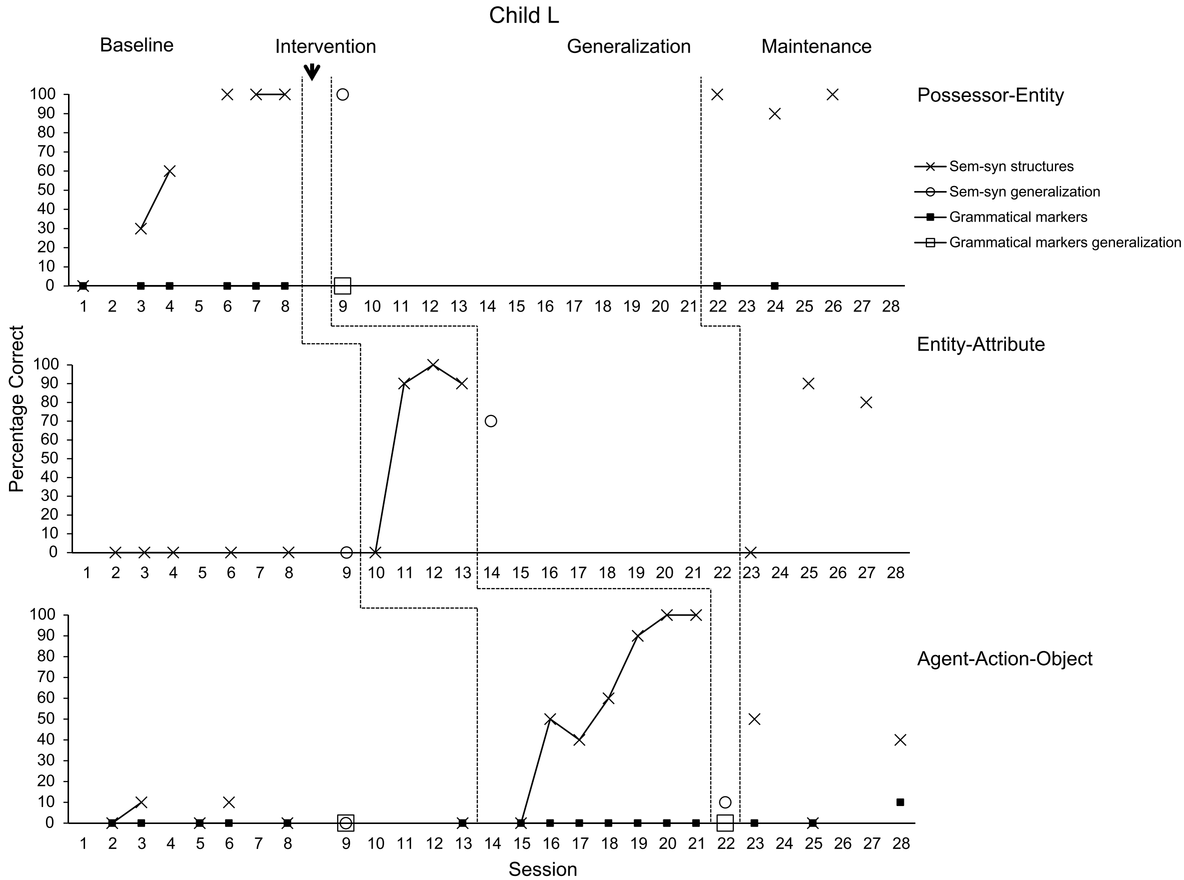


baseline phase. Multiple reasons may help account for this loss of control. First, the participants completed a DA task before starting the baseline phase. This task, discussed in detail in this article's companion (Binger et al., 2017), provided the children with multiple opportunities to practice producing each target; 10 graduated prompting trials were administered for each target. Given indications in past research of the challenges 3- and 4-year-olds experience with producing graphic symbol sentences (Sutton et al., 2010), we did not anticipate that these relatively brief DA sessions would significantly affect performance on the dependent measures. However, the sessions did appear to affect performance of at least one target for five participants. To examine this, the first baseline session for each target was examined to see whether children demonstrated at least moderate accuracy (50% or better); carryover effects cannot be ruled out for the second, third, and fourth targets. This occurred for five participants: Children G, K, and M all produced the possessors with at least 50% accuracy in their first baseline session, Child J produced all four targets at or above this criterion, and Child N produced three. The DA results for these children are similar to the findings for the four 5-year-olds in King et al. (2015), in which DA performance was compared with a condition akin to the first baseline phase in the present study.

DA performance, however, does not fully explain the loss of experimental control, because some children demonstrated learning during the baseline phase, that is, a positive slope over multiple sessions. For example, five children (I, J, H, L, and O) took more than the minimum of three sessions to reach mastery for possessors, demonstrating improved performance over time. Although most common for the possessors, this occurred with additional targets as well—most clearly for the attributes for Children J and N. These data seem to indicate that the so-called baseline condition, in which the intention was to merely track performance, actually acted as an intervention for some children on some targets; learning over multiple sessions for the first target occurred in four of 10 cases: Children J and L for possessors, Child G for AAO, and Child M for locatives. The baseline task itself, then, appeared to be conducive to learning in some cases.

Examining patterns across targets also is informative, particularly because broad claims of children having difficulties creating graphic symbol sentences have been

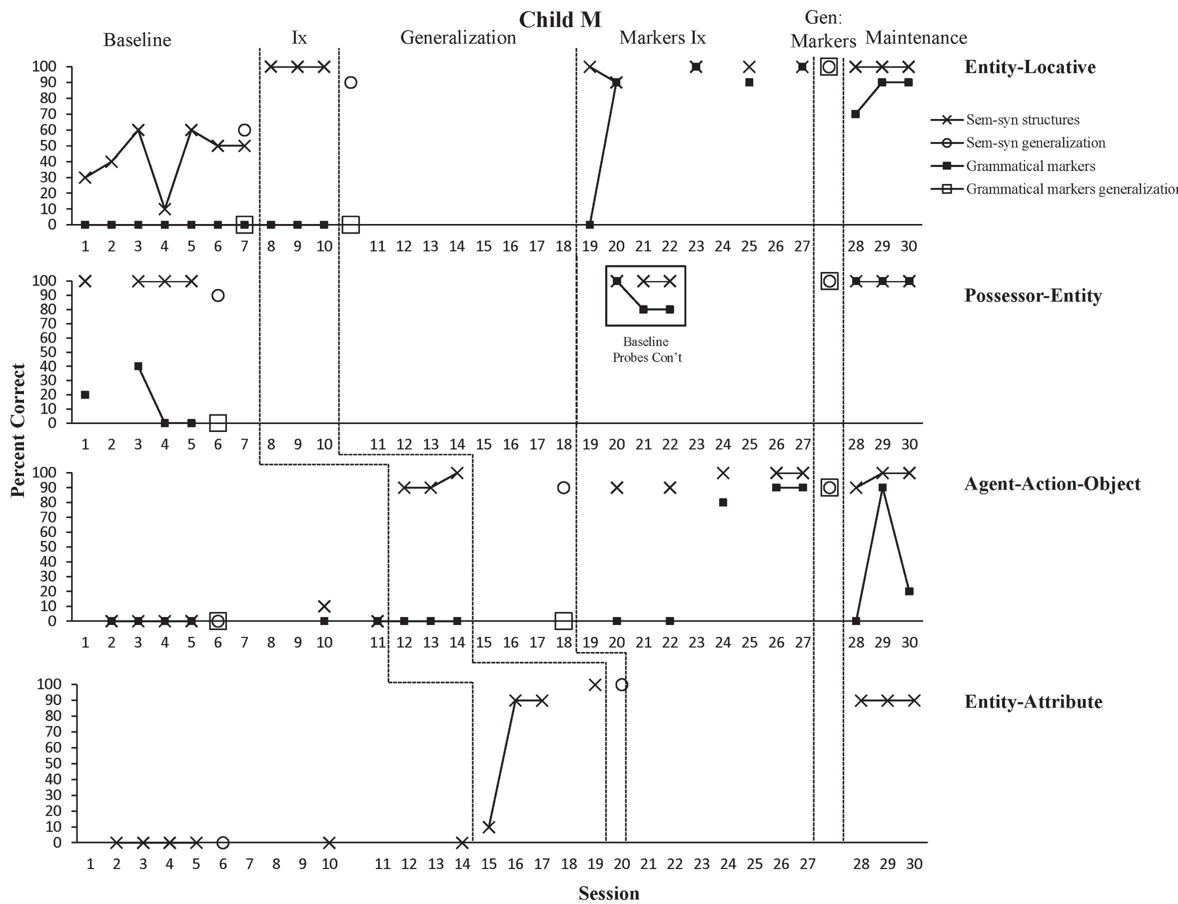
Figure 6. Results for Child L. Sem-syn = semantic–syntactic.



made on the basis of a limited range of targets (Sutton et al., 2010; Trudeau, Sutton, Dagenais, DeBroeck, & Morford, 2007; Trudeau et al., 2010). The most obvious pattern that emerged in the current study was the fact that nine of 10 children mastered possessor-entity during baseline. In spoken language development, possessor-entity is one of the earliest word combinations to emerge (Leonard, 1976), which likely contributed to success. In addition, both components of this semantic relation were represented by visually salient characters and objects (e.g., *MICKEY PLATE*), as opposed to the more abstract representations required for the locatives (e.g., *IN, ON*), actions (e.g., *DROP, CHASE*), and attributes (e.g., *WET, DRY*). In contrast to the possessors, the most challenging target was reversible AAO (*MICKEY KISS PLUTO*). Four of 10 children failed to master this target, with two making no progress (Children I and K), and an additional four participants (Children L, N, O, and P) did not consistently demonstrate generalized use to novel vocabulary or consistently maintain this structure. As discussed in the results, no consistent error patterns across children were noted, a finding consistent with past research involving children who are typically developing (Sutton et al., 2010).

A range of factors could have contributed to the differences in performance noted across targets, particularly when comparing the current findings with the work of Sutton and colleagues (e.g., Poupart et al., 2013; Sutton et al., 2010). Many factors across these various studies differed, such as layout (grids vs. individual symbols), presence or absence of voice output, nature of the stimuli (video clips vs. static photos), and amount of instruction. What is perhaps most instructive, then, is to examine differences across targets within the present study because fewer variables changed from target to target. The three most obvious differences between the easiest (possessors) and hardest (AAO) targets in the current study include (a) two-symbol versus three-symbol target; (b) all concrete symbols versus some abstract symbols; and (c) moving from left to right on the display to create messages versus violation of that pattern (i.e., left-right-left for AAO). Notably, however, the two moderately easy targets—entity-attribute and entity-locative—were three-symbol targets that involved the use of abstract symbols, so the first two items are unlikely culprits. Regarding the movement pattern from left to right, it is not possible to know whether this affected the results with the current design. However, it is notable that

Figure 7. Results for Child M. Sem-syn = semantic–syntactic; cont'd = continued.



the typically developing 3- and 4-year-olds in Sutton et al. (2010), who used individual paper-based symbols instead and therefore were not locked into particular patterns, still demonstrated challenges with reversible AAO. It seems likely, then, that part of the difficulty for 3- and 4-year-olds is the target itself, rather than setup of the task. Given that the reversible AAO structure is a later developing target (approximately 48 months) in typical language development (Miller & Paul, 1995), perhaps the noted challenges should not be surprising. Indeed, having six of eight 4-year-olds achieving mastery may demonstrate a level of competence with graphic symbol productions that comes close to mirroring what occurs in spoken language development for this particular target.

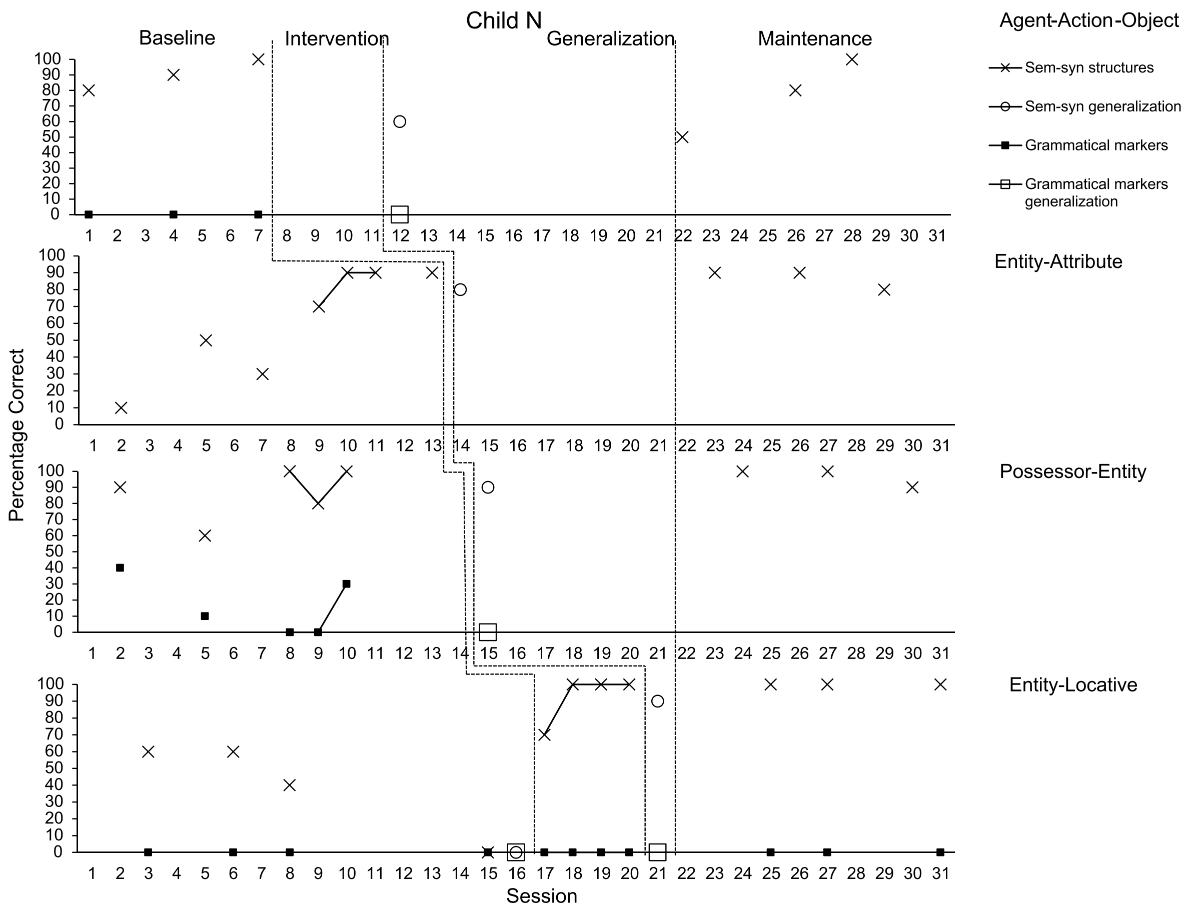
Generalization (Aim 2)

Data were collected to track participants' ability to generalize use of learned structures to novel vocabulary, for example, producing "*Turtle is thirsty*" instead of "*Goofy is wet*" for entity-attribute. Due to the high number of video probe sessions required to track the dependent measure, limited generalization data were collected (i.e., typically one probe per target in baseline and in generalization). Most participants generalized use of learned structures to novel vocabulary, with notably weaker performances for the two 3-year-olds (O and P). In addition, the dependent task itself necessitated a level of generalization across vocabulary; that is, the characters used in the DA and play sessions (e.g., Lion, Monkey) differed from the characters in the video probes (e.g., Mickey Mouse, Minnie Mouse). The participants appeared to apply underlying linguistic rules to their productions, then, because they could not have simply memorized the sentences. It must be noted, however, that the placement of generalization targets on the displays adhered to the same format used for the dependent measures (e.g., agents on the left).

Production of Grammatical Markers (Aim 3)

Symbols for relevant grammatical markers were provided on the communication displays to collect initial pilot data. We found it fascinating that nine participants spontaneously used the possessive marker accurately at least once with no aided models provided; four of these participants

Figure 8. Results for Child N. Sem-syn = semantic–syntactic.



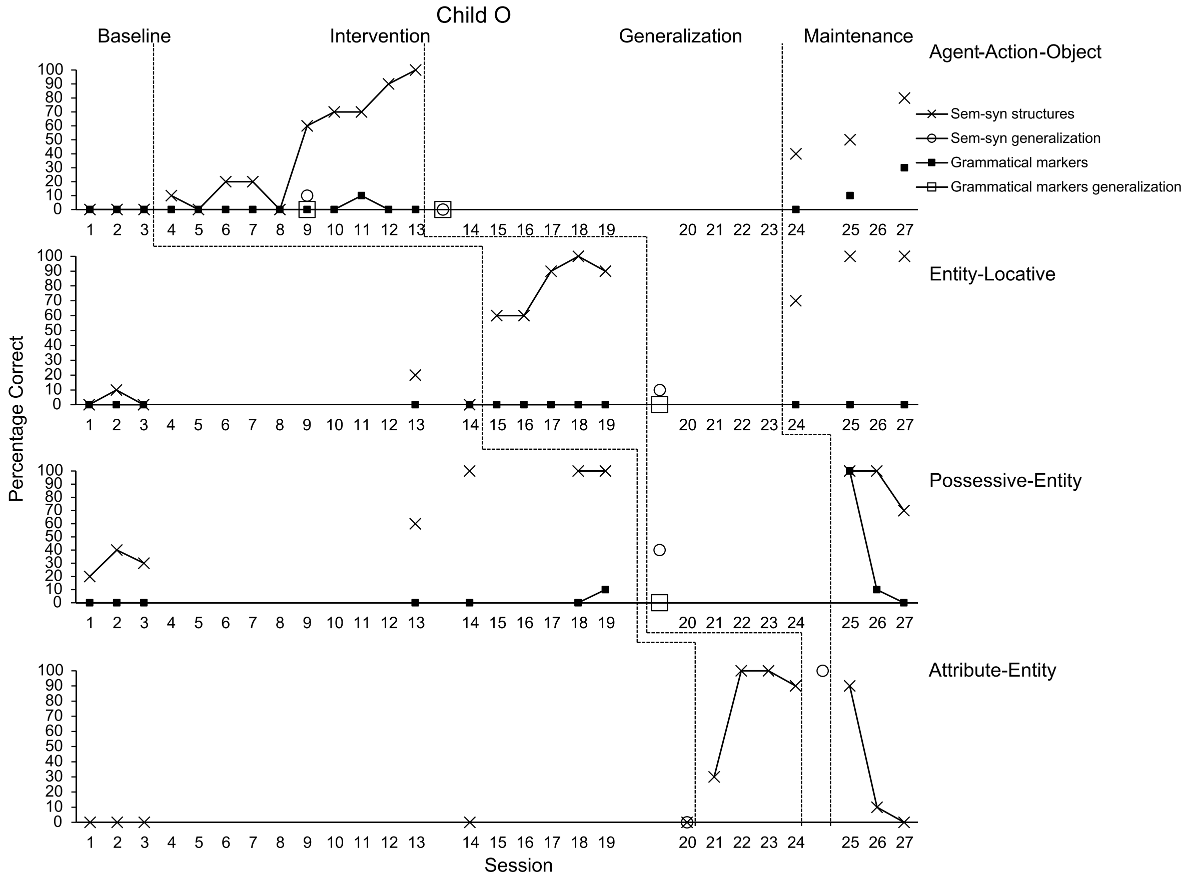
(Children G, H, J, and M) demonstrated consistent use across multiple sessions. In addition, Child O demonstrated emerging use of the third-person singular marker ("*Mickey drop* + *s Goofy*") with no instruction. One feasible explanation is that participants simply wanted the voice output to "sound right" when they played back their messages; that is, "*Minnie's plate*" clearly depicts a possessor-entity relationship, but "*Minnie plate*" does not. The possessive marker, then, appeared to be a particularly salient marker.

Furthermore, Children H, J, M, and K were taught to explicitly use grammatical markers, with all four rapidly learning to use these symbols accurately; they required only one to two intervention sessions to demonstrate consistent use of the markers. These initial data are both highly encouraging, in that the findings offer hope that young children with severe speech impairments can be provided with ways to produce grammatically complete messages akin to their peers, and also quite disconcerting in that such targets have largely been considered beyond the reach of young children. Given that the presence of disability plays such a large role in, for example, educational placement decisions (National Center for Educational Statistics, 2013), this is cause for great concern. Clearly, additional research is needed to further explore preschool use of a much broader range of grammatical markers within graphic symbol messages.

Limitations and Directions for Future Research

The most apparent limitation of the present investigation is that experimental control was not maintained for five of 10 participants, primarily due to the fact that some of the targets were mastered during baseline—a limitation tempered by the fact that these 3- and 4-year-olds were capable of producing the targets. Additional work is required to further refine which children are ready to produce which targets—a need highlighted by the performance of Children I and K, who mastered at least two targets but made no progress at all on one. DA, the focus of the companion article (Binger et al., 2017), holds promise in this regard. The children's performances on DA tasks were significantly correlated with their performances during subsequent sessions for some targets; that is, targets produced accurately and quickly during DA required relatively little intervention, and vice versa. Using DA to determine

Figure 9. Results for Child O. Sem-syn = semantic–syntactic.



which targets are within a child's zone of proximal development (Vygotsky, 1978) may help prevent the loss of experimental control in future studies of this kind. Careful attention to the timing of DA, however, must be considered in future work. In the current study, DA was executed prior to baseline, calling the very nature of the baseline phase into question; that is, the baseline phase may have served as more of a learning condition than a true baseline—a learning phase possibly stimulated by the DA condition.

In addition, systematic investigation of children with profiles different from those in the current study are needed. Emerging evidence indicates that children with cognitive impairments, for example, can learn to create rule-based graphic symbol messages (Nigam et al., 2006; Tönsing, 2015; Tönsing et al., 2014), and research including greater numbers of participants with specific cognitive and linguistic profiles will provide a deeper understanding of the learning process for different children.

Conclusions

The results of this study indicate that some preschoolers requiring AAC with relatively intact receptive language can readily learn to construct a range of rule-based sentences using graphic symbols—and, at times, with minimal instruction. Furthermore, some children can readily be taught (or, in some cases, will spontaneously begin) to use grammatical markers to create grammatically complete messages when they are provided with access to relevant grammatical markers. These highly encouraging findings indicate the need to recalibrate expectations for at least some young children who require AAC, providing them with viable communication modes and effective interventions to maximize expressive language potential.

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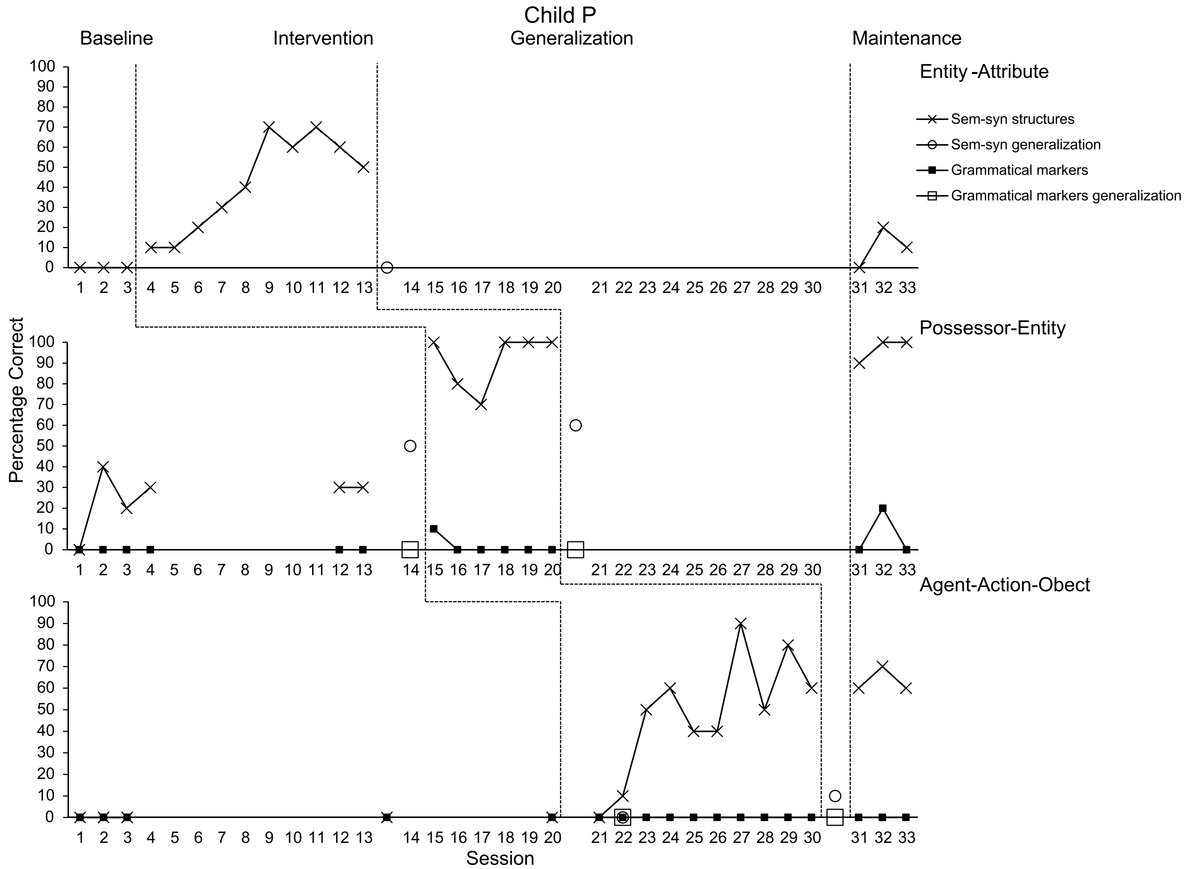
Figure 10. Results for Child P. Sem-syn = semantic–syntactic.



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References

Arnold, B. (Producer), Catmull, E. (Executive Producer), Guggenheim, R. (Producer), Job, S. (Executive Producer), & Lasseter, J. (Director). (1995). *Toy story* [Motion picture]. United States: Pixar Animation Studios/Walt Disney Pictures.

Binger, C., Kent-Walsh, J., Berens, J., Del Campo, S., & Rivera, D. (2008). Teaching Latino parents to support the multi-symbol message productions of their children who require AAC. *Augmentative and Alternative Communication, 24,* 323–338. https://doi.org/10.1080/07434610802130978

Binger, C., Kent-Walsh, J., Ewing, C., & Taylor, S. (2010). Teaching educational assistants to facilitate the multi-symbol message productions of young students who require augmentative and alternative communication. *American Journal of Speech-Language Pathology, 19,* 108–120. https://doi.org/10.1044/1058-0360

Binger, C., Kent-Walsh, J., & King, M. (2017). Dynamic assessment for 3- and 4-year-old children who use augmentative and alternative communication: Evaluating expressive syntax. *Journal of Speech, Language, and Hearing Research.* Advance online publication. https://doi.org/10.1044/2017_JSLHR-L-15-0269

Binger, C., Kent-Walsh, J., King, M., Webb, E., & Buenviaje, E. (2016). Early sentence productions of 5-year-old children who use augmentative and alternative communication. *Communication Disorders Quarterly*. Advance online publication. https://doi.org/10.1177/1525740116655804

Binger, C., & Light, J. C. (2006). Demographics of preschoolers who require AAC. *Language, Speech, and Hearing Services in Schools, 37,* 200–208. https://doi.org/10.1044/0161-1461(2006/022)

Binger, C., & Light, J. (2007). The effect of aided AAC modeling on the expression of multi-symbol messages by preschoolers who use AAC. *Augmentative and Alternative Communication, 23,* 30–43. https://doi.org/10.1080/07434610600807470

Binger, C., Ragsdale, J., & Bustos, A. (2016). Language sampling for preschoolers with severe speech impairments. *American Journal of Speech-Language Pathology, 25,* 493–507. https://doi.org/10.1044/2016_AJSLP-15-0100

Courtright, J. A., & Courtright, I. C. (1979). Imitative modeling as a language intervention strategy: The effects of two mediating variables. *Journal of Speech and Hearing Research, 22,* 389–402.

Fenson, L., Marchman, V. A., Thal, D. J., Dale, P. S., Reznick, S. J., & Bates, E. (2007). *MacArthur Communicative Development Inventories–Second Edition*. Baltimore, MD: Brookes.

Kent-Walsh, J., Binger, C., & Buchanan, C. (2015). Teaching children who use augmentative and alternative communication to ask inverted yes-no questions using aided modeling. *American Journal of Speech-Language Pathology, 24,* 222–236. https://doi.org/10.1044/2015_AJSLP-14-0066

Kent-Walsh, J., Binger, C., & Malani, M. D. (2010). Teaching partners to support the communication skills of young children who use AAC: Lessons from the ImPAACT program. *Early Childhood Services, 4,* 155–170.

King, M., Binger, C., & Kent-Walsh, J. (2015). Using dynamic assessment to evaluate the expressive syntax of children who use augmentative and alternative communication. *Augmentative and Alternative Communication, 31,* 1–14. https://doi.org/10.3109/07434618.2014.995779

Kratochwill, T. R., Hitchcock, J., Horner, R. H., Levin, J. R., Odom, S. L., Rindskopf, D. M., & Shadish, W. R. (2010). Single-case design technical documentation. Retrieved from http://ies.ed.gov/ncee/wwc/pdf/wwc_scd.pdf

Leonard, L. B. (1976). *Meaning in child language: Issues in the study of early semantic development*. New York, NY: Grune & Stratton.

McDonald, E., & Schultz, A. (1973). Communication boards for cerebral palsied students. *Journal of Speech and Hearing Disorders, 38,* 73–88.

Miller, J. F., & Paul, R. (1995). *The clinical assessment of language comprehension*. Baltimore, MD: Brookes.

National Center for Educational Statistics. (2013). Percentage distribution of students 6 to 21 years old served under Individuals With Disabilities Education Act (IDEA), Part B, by educational environment and type of disability: Selected years, fall 1989 through fall 2011. Retrieved from https://nces.ed.gov/programs/digest/d13/tables/dt13_204.60.asp

National Joint Committee for the Communicative Needs of Persons With Severe Disabilities. (1992). Communication bill of rights. *Asha, 34*(Suppl. 7), 2–3.

Nigam, R., Schlosser, R. W., & Lloyd, L. L. (2006). Concomitant use of the matrix strategy and the mand-model procedure in teaching graphic symbol combinations. *Augmentative and Alternative Communication, 22,* 160–77. https://doi.org/10.1080/07434610600650052

Parker, R., Vannest, K. J., & Brown, L. (2009). The improvement rate difference for single-case research. *Council for Exceptional Children, 75,* 135–150.

Paul, R., & Norbury, C. (2012). *Language disorders from infancy through adolescence: Listening, speaking, writing, and communicating* (4th ed.). St. Louis, MO: Elsevier Mosby.

Poupart, A., Trudeau, N., & Sutton, A. (2013). Construction of graphic symbol sequences by preschool-aged children: Learning, training, and maintenance. *Applied Psycholinguistics, 34,* 91–109.

Romski, M., Sevcik, R. A., Adamson, L. B., Smith, A., & Barker, R. M. (2010). Randomized comparison of augmented and nonaugmented language interventions for toddlers with developmental delays and their parents. *Journal of Speech, Language, and Hearing Research, 53,* 350–365.

Shriberg, L. D., Fourakis, M., Hall, S. D., Karlsson, H. B., Lohmeier, H. L., McSweeny, J. L., . . . Wilson, D. L. (2010). Extensions to the speech disorders classification system (SDCS). *Clinical Linguistics & Phonetics, 24,* 795–824. https://doi.org/10.3109/02699206.2010.503006

Sutton, A., Trudeau, N., Morford, J., Rios, M., & Poirier, M.-A. (2010). Preschool-aged children have difficulty constructing and interpreting simple utterances composed of graphic symbols. *Journal of Child Language, 37,* 1–26. https://doi.org/10.1017/S0305000909009477

Tönsing, K. M. (2015). Supporting the production of graphic symbol combinations by children with limited speech: A comparison of two AAC systems. *Journal of Developmental and Physical Disabilities*. Advance online publication. https://doi.org/10.1007/s10882-015-9425-5

Tönsing, K. M., Dada, S., & Alant, E. (2014). Teaching graphic symbol combinations to children with limited speech during shared story reading. *Augmentative and Alternative Communication, 30,* 279–297. https://doi.org/10.3109/07434618.2014.965846

Trudeau, N., Sutton, A., Dagenais, E., DeBroeck, S., & Morford, J. (2007). Construction of graphic symbol utterances by children, teenagers, and adults: The effect of structure and task demands. *Journal of Speech, Language, and Hearing Research, 50,* 1314–1330.

Trudeau, N., Sutton, A., Morford, J. P., Côté-Giroux, P., Pauzé, A.-M., & Vallée, V. (2010). Strategies in construction and interpretation of graphic-symbol sequences by individuals who use AAC systems. *Augmentative and Alternative Communication, 26,* 299–312. https://doi.org/10.3109/07434618.2010.529619

Vannest, K., Parker, R., & Gonen, O. (2011). Single case research [Web based calculations for single-case research analysis]. Retrieved from http://www.singlecaseresearch.org

Vygotsky, L. S. (1978). *Mind in society*. Cambridge, MA: Harvard University Press.