AJSLP

Research Article

Effects of a Least-to-Most Prompting Procedure on Multisymbol Message Production in Children With Autism Spectrum Disorder Who Use Augmentative and Alternative Communication

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Purpose: In this study, we investigated the efficacy of a least-to-most (LTM) prompting procedure (Ault & Griffen, 2013; MacDuff, Krantz, & McClannahan, 2001; Neitzel & Wolery, 2009) for increasing use of multisymbol messages in school-age children with autism spectrum disorder (ASD) who use augmentative and alternative communication (AAC) during a storybook reading activity.
Method: In the study, we used a single-subject, multiple-probe research design across participants (Kazdin, 1982) with 6 children (ages 8–12) with ASD and who used AAC systems for communication. There were 4 phases in this investigation: (a) baseline, (b) intervention, (c) generalization, and (d) maintenance.
Results: All participants exhibited a positive increase in multisymbol message production almost immediately upon introduction of the LTM prompting procedure.
Conclusions: The results of the investigation contribute important information on the efficacy of the LTM prompting procedure for teaching use of multisymbol messages to school-age children with ASD who use AAC.

Several models exist for conceptualizing disability. In particular, the biopsychosocial model adopted by the World Health Organization (WHO, 2002) and the social model taken up within disability studies (Straus, 2013) emphasize the role of contextual factors in shaping an individual's functioning and participation. In contrast, the medical model emphasizes the role of individual skills and abilities. Consistent with the latter, the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition* characterizes autism spectrum disorder (ASD) by deficits in the following areas: social interaction and social communication paired with restrictive and repetitive behavior patterns, activities, or interests (American Psychiatric Association, 2013). A rough estimate is that 20%–50% of individuals with ASD do not develop functional natural speech (Lord, Risi, & Pickles, 2004; National Research Council, 2001). Because of this, augmentative and alternative communication (AAC) is often recommended to meet their daily communication needs (Lord et al., 2004). AAC provides a potential intersection between both the medical and social models of ASD because it offers a contextual support for linguistic deficits in the individual (Lord et al., 2004; Robertson, 2010).

Over the years, the number of intervention options available for children with ASD has grown exponentially. According to the National Standards Project, Phase 2, from the National Autism Center (NAC, 2015), there is compelling scientific evidence for 14 different "established treatments" for individuals with ASD under the age of 22. Of those, 11 are specifically stated to be effective for intervention related to communication. Only five of these interventions (i.e., behavioral interventions, modeling, peer training package, scripting, and story-based interventions), however, are stated to be effective for teaching communication to children with ASD over the age of 9 years (NAC, 2015). There is especially limited information about the effects of intervention for school-age children with ASD who rely on

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Correspondence to Erinn H. Finke: enh109@psu.edu
Editor: Joe Reichle
Associate Editor: Laura DeThorne
Received October 30, 2014
Revision received May 11, 2015
Accepted June 10, 2016
DOI: 10.1044/2016_AJSLP-14-0187

Disclosure: *The authors have declared that no competing interests existed at the time of publication.*

AAC for communication (Tager-Flusberg et al., 2009). The efficacy research for teaching language skills that extend beyond simple requests is even more limited (National Research Council, 2001). This is a major challenge that requires immediate attention because communication and language learning are significant challenges for children with ASD (Wetherby & Prizant, 2005) and for children who use AAC (e.g., Lund & Light, 2007).

One particular language challenge for children who use AAC, including those with ASD, is their tendency to communicate using predominantly single-symbol messages (Light, Binger, & Kelford Smith, 1994; Smith & Grove, 2003). This major difference in communication patterns is significant because communicating using longer, more complex utterances and meeting the full range of communicative demands across contexts is an important stage of language development and critical to competent communication (Branson & Demchak, 2009; Hamm & Mirenda, 2006). For this reason, supporting learning of new and increasingly more sophisticated language (i.e., use of longer utterances involving multisymbol messages) should be a primary goal of intervention with children with ASD who use AAC (e.g., Light, Roberts, Dimarco & Greiner, 1998).

Intervention using a least-to-most (LTM) prompting procedure may be one way to facilitate language learning and, to be specific, the transition to multisymbol messages (i.e., two or more symbols combined to communicate one message) for children with ASD who use AAC. *Prompting* is generally defined as a support that facilitates the use of a specific skill (Neitzel & Wolery, 2009). LTM prompting (i.e., system of least prompts, increasing assistance) is a specific type of prompting procedure designed to begin teaching with a natural cue and continue with the provision of systematically more intrusive cues until the target skill is demonstrated (Ault & Griffen, 2013). Prompting is generally one of multiple components in behavioral interventions (NAC, 2015), but it has also been used, much less frequently, as a single component intervention (e.g., West & Billingsley, 2005) to teach various skills to children with ASD (Neitzel & Wolery, 2009). Therefore, the purpose of this study was to investigate the efficacy of prompting using a LTM prompting procedure for teaching the production of multisymbol messages to children with ASD who used AAC systems to communicate during a storybook reading activity. The literature reviewed in the following section focuses first on the limited research related to the independent variable, using LTM prompting procedures to teach skills to children with ASD; then the intervention context, storybook reading; and last, the literature on teaching multisymbol messages to children with ASD who use AAC.

Literature Review

The bulk of the literature in special education has demonstrated that children with ASD need frequent practice as well as regular and consistent feedback during the process of learning new skills (e.g., Drain & Engelhardt, 2013; Goldstein, 2002; Hauck, Fein, Waterhouse, & Feinstein, 1995; Keen, Sigafoos, & Woodyatt, 2005). This can be challenging because children with ASD may not learn from everyday tasks and environments in the same ways as people without ASD (Hudson, Nijboer, & Jellema, 2012). One effective method for teaching children with ASD new skills is to provide them with prompts (MacDuff et al., 2001). Prompts can serve many functions in teaching new skills (e.g., as an antecedent or consequence to a behavior), but in the traditional sense, a prompt is a stimulus that is presented either just before or just after the natural cue for a target behavior. There are many different types of prompts that have been used to teach skills to children with ASD in the research literature (MacDuff et al., 2001).

The Independent Variable: LTM Prompting

In LTM prompting, a hierarchy of at least three levels of prompts, beginning with a natural cue, is used to teach a target skill. Subsequent prompts are provided in a sequence from the least amount of support to the most amount of support until the target skill is performed accurately (Ault & Griffen, 2013). What makes LTM instructive is the opportunity to determine the types of prompts that are necessary for the child with ASD to be able to produce the target response (MacDuff et al., 2001). LTM prompting procedures have been used to teach various skills to children with ASD (e.g., Cihak, Fahrenkrog, Ayres, & Smith, 2010; Heckaman, Alber, Hooper, & Heward, 1998; Taylor & Hoch, 2008; Yanardag et al., 2011), children who use AAC (e.g., Beukelman & Mirenda, 2013), and children with ASD who use AAC (e.g., Dyches, 1998; Son, Sigafoos, O'Reilly, & Lancioni, 2006).

Children With ASD

Taylor and Hoch (2008) used a multiple-baseline, across-participants research design and an LTM prompting hierarchy to successfully teach three children with ASD to respond to bids for joint attention by instructing them to (a) look in the direction of a point, (b) comment about the item being pointed to, and (c) look back at the instructor. Yanardag et al. (2011) also used a single-subject research design (i.e., multiple probe across skills) and LTM prompting procedures to teach children with ASD basic tennis skills. West and Billingsley (2005) compared the efficacy of a traditional LTM prompting procedure with a revised LTM prompting procedure using a parallel treatments design (i.e., two concurrently implemented multiple-probe designs across behaviors) to teach children with ASD basic life skills (e.g., pouring a drink and watering plants) and receptive identification of words. These researchers found that both LTM prompting procedures were effective; however, the revised prompting procedure was more efficient. Cihak et al. (2010) used an ABAB single-subject research design to teach children with ASD to use an iPod video to transition between tasks, and Heckaman et al. (1998) used an alternating treatments design and an LTM prompting procedure to decrease disruptive behaviors exhibited by children with ASD.

Children With ASD Who Use AAC

LTM prompting procedures have also been shown to be effective in teaching individuals with ASD who use AAC systems for various communication skills. Dyches (1998) used LTM prompting procedures and a single-subject ABAB research design to teach four children with ASD to use a switch to communicate and access an AAC system. Son et al. (2006) used an LTM prompting procedure and a multiple-baseline, across-participants design to teach preschool-age children with ASD to use two different AAC systems (i.e., Tech/Talk 6X8 and the Picture Exchange Communication System) to request various food items.

Although the current literature represents a good start at better understanding the utility of this type of prompting system for teaching new skills to both children with ASD and children who use AAC, gaps persist. First, there have been no studies to date that have examined the maintenance of effects observed in research investigations. Second, expressive language functions beyond expression of requests have not been targeted. Further, there is a lack of research investigating the use of this approach to teach language skills within naturalistic activities, particularly joint storybook reading.

The Intervention Context: Storybook Reading

Designing effective language interventions for children with ASD can be challenging. According to Bellon, Ogletree, and Harn (2000), approaching communication intervention from a natural, transactional perspective has become the favored approach. From this perspective, "trainers assume responsibility for procedures while attempting to maintain a naturalness conducive to generalizable learning" (p. 52). To achieve this form of intervention, activities in which the child with ASD and the partner can share attention and take turns equally are paramount. Therefore, storybook reading may be an appropriate context for natural, meaningful language learning opportunities (Stephenson, 2009). Storybook reading creates a joint frame of reference between the person implementing the intervention and the child with ASD. In addition, storybook reading promotes turn-taking and encourages the child with ASD who uses AAC to participate in the interaction (Kaiser, Hester, & McDuffie, 2001). Storybooks provide a predictable routine and a narrow range of potential referents, which can make it easier for the child with ASD and the interventionist to recognize and establish appropriate language patterns. The storybook context has been shown to be effective for language learning in typically developing populations (e.g., Justice, Meier, & Walpole, 2005; Ninio & Bruner, 1978). Because of the inherent structure provided by the storybook context, an adult interventionist may be better able to provide appropriate scaffolding and prompting to elicit target language skills (Bellon et al., 2000; Stephenson, 2009).

Further, research has indicated children with ASD tend to engage more when activities are ones they prefer (Koegel, Dyer, & Bell, 1987), when activities and the materials are predictable (Ferrara & Hill, 1980), and when the activity contains more structure (DeKlyen & Odom, 1989). For these reasons, a storybook reading interaction was selected as the context for the current intervention.

The Dependent Variable: Multisymbol Message Production

Children With ASD Who Use AAC

There is limited extant research on teaching the expression of multisymbol messages using any type of intervention approach to school-age children with ASD who use AAC. Nigam (1999) used a matrix training strategy and the mand-model procedure within a single-subject research design to teach graphic symbol combinations to two children with ASD who used AAC with mixed results. One child demonstrated increases in use of multisymbol messages to label actions with objects, and the other child did not demonstrate increases in the target skill. Nigam, Schlosser, and Lloyd (2006) also used a matrix strategy and mand-model procedure within a multiple-probe research design across sets of action–object combinations to teach three children with ASD to combine graphic symbols to formulate action–object phrases. The results of this intervention study were also mixed, with two of the three participants acquiring the targeted language form.

Children Without ASD Who Use AAC

Other researchers have demonstrated the ability to teach various communication partners a strategy for supporting the production of multisymbol messages by children with disabilities other than ASD who use AAC systems. For example, Binger, Kent-Walsh, Berens, Del Campo, and Rivera (2008) used a cognitive strategy instructional approach (i.e., an eight-step strategy instruction approach to teach communication partners of children who use AAC the strategy *read, ask, answer*; see Kent-Walsh & McNaughton, 2005) within a multiple-probe, across-participants design to teach Latino parents to support the production of multisymbol messages in their children with severe speech impairment. The results of this study indicated the parents could learn to use the interaction strategy (i.e., read, ask, answer) to support increased production of multisymbol messages by their children on average by six to nine turns during 10-min interactions.

Binger, Kent-Walsh, Ewing, and Taylor (2010) used similar strategy instruction procedures within a multiple-probe, across-participants design to teach educational assistants to facilitate multisymbol message production in children with general developmental delays and/or cerebral palsy. Results of this study were also positive and indicated the use of the strategy facilitated increased use of multisymbol messages by seven to 10 different multisymbol messages during 10-min interactions.

There is clearly an emerging literature on the efficacy of various types of interventions for teaching the production of multisymbol messages to children (with a variety of disabilities) who use AAC systems to communicate. There is additional literature on effective methods for training

communication partners to use a specific strategy to support the production of multisymbol messages by children who use AAC. However, to date there are no published studies that have examined LTM prompting procedures to teach multisymbol productions to children with ASD who use AAC. The current study bridges this gap.

Current Project

The current project used an LTM prompting procedure and a multiple-probe, across-participants design to teach children with ASD, who use AAC to communicate, to use multisymbol messages during storybook reading. It was expected that (a) the LTM prompting procedure would be effective for teaching the production of multisymbol messages within the storybook reading interactions, and (b) the use of multisymbol messages would generalize to untrained storybook reading interactions once learned in intervention. Therefore, the specific research question was the following: What is the effect of an LTM prompting procedure on the production of multisymbol messages by school-age children with ASD who use AAC during storybook reading interactions?

Method

Research Design

The current study used a single-subject, multiple-probe research design across two separate cohorts of three children with ASD who used AAC. As such, the study offered the opportunity for replication of treatment effects both within and across cohorts. Although three or more replications is the traditional standard in single-subject research designs (Horner, Sturmey, & Zarcone, 2010), a cohort design reduced the wait time in baseline for the learners while still demonstrating replication of the treatment effect. Replication of the effect of the independent variable helped address internal validity concerns sometimes associated with research using single-subject research designs (Kratochwill et al., 2010).

Participants

Potential participants were recruited through a school for children with severe ASD in central Pennsylvania with which the first author has an established working relationship. Prior to initiation of any research activity related to the current project, the first author met with the associate director of the school at which the study was conducted. The first author described the purpose and goals of the project as well as the communication characteristics of potential participants (e.g., children who communicate using single-symbol messages, who don't currently use multisymbol combinations) and inquired if the associate director felt any of the children in the school were functioning at this stage of development. The associate director, in collaboration with classroom teachers, generated a list of 10 children who they felt, on the basis of discussions with the first author, might be appropriate for the study. The first author then observed all 10 children in their classroom setting and, on the basis of this observation in conjunction with further discussions with the classroom teachers, included all 10 children in the project.

Permission to participate in the research project was sought and obtained from the parents of all 10 children. Six of the original 10 children were ultimately included in the current study. The other four children did not meet the confirmatory inclusion criteria collected during baseline sessions, indicating learning to use multisymbol messages was not an appropriate intervention target for these children given their current needs and skills. These children, therefore, took part in an alternate intervention that was more appropriate for their communicative stage. See Table 1 for additional demographic information about the six participants included in the current project.

The six participants were children with ASD between the ages of 8 and 12 years who used AAC and who met

Table 1. Participant demographic information.

Name	Age	Gender	Race/ethnicity	Diagnosis (age at diagnosis)	Comorbid diagnoses	AAC systems used prior to the intervention
Corey	12	Male	Caucasian	ASD (21 months)	Crohn's disease, acid reflux, streptococcus	PECS, gestures, some ASL
Tiffany	10	Female	Biracial (African American/ Caucasian)	ASD (36 months)	Eczema, allergies	iPad (Proloquo2Go), gestures
Zach	9	Male	Caucasian	ASD (34 months)		iPad (Proloquo2Go), Vantage Lite, gestures, vocalizations
Pamela	13	Female	Caucasian	ASD (24 months)	Myotonic dystrophy	Single words, ASL, communication book
Mark	10	Male	Hispanic	ASD (36 months)	Jaundice, sleeping issues	iPad (Proloquo2Go), PECS, vocalizations
Evan	12	Male	Caucasian	ASD (22 months)	Medulloblastoma, GERD, Hypothyroidism	Communication book, gestures, vocalizations

Note. AAC = augmentative and alternative communication; ASD = autism spectrum disorder; PECS = Picture Exchange Communication System; ASL = American Sign Language; GERD = gastroesophageal reflux disorder.

several initial and confirmatory inclusion criteria. Inclusion criteria were based on parent and teacher report, school record review, researcher observation in the classroom setting, and participation in baseline storybook reading interactions. The confirmatory criteria for participation in the current investigation were based on criteria indicating a "first words" stage of language development (Tager-Flusberg et al., 2009) and included (a) expressive communication that consisted of no more than two spontaneous multisymbol messages across all baseline storybook reading interactions, (b) expression of at least 15 different single-symbol messages via any symbolic mode of communication (word, icon, sign) but expression of no more than five spoken words total across all baseline sessions, (c) use of at least two different communicative functions (e.g., request object and protest as defined and operationalized using the behavioral evidence outlined in Wetherby & Prutting, 1984) across all baseline sessions, (d) hearing or corrected hearing functional for participation in language intervention in a quiet room on the basis of parent report and school screening data, (e) vision or corrected vision functional for accessing an AAC device on the basis of parent report and school screening data, and (f) verification of an ASD diagnosis by an outside professional using the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (American Psychiatric Association, 2000) criteria on the basis of school record review. Because the school that all of the participants attended is self-contained and specifically for children with ASD, documentation of a formal ASD diagnosis and the criteria used to make the diagnosis were part of each child's formal educational record.

All participants in this investigation used multimodal communication strategies, including high-tech AAC (e.g., iPad), light-tech AAC (e.g., communication book), sign language, gestures, vocalizations, and/or speech or speech approximations. Students accessed their AAC systems by using direct selection with a finger. Any AAC system the student typically used (or had available throughout the school day) was present and accessible during all phases and sessions. Four of the six participants had experience using an iPad with the application Proloquo2Go prior to participation in the current investigation.

Corey

Corey started attending the specialized school for children with ASD at which the study took place when he was 5 years and 9 months old. At the time of the study, Corey was on medication for aggression and self-injurious behaviors. As stated by his parents and reported in an evaluation completed by his school, no formal intervention occurred in the home. Corey's individualized education program (IEP) goals at school focused on following a continuum of simple-to-complex directions, counting and sorting functional items, performing functional activities and tasks, pragmatic skills, social closeness, increasing vocabulary and syntax production, and using his AAC system for communication.

Tiffany

Tiffany was diagnosed with ASD and concomitant psychological stressors and intrinsic stress secondary to her developmental disorder. Tiffany's parents reported Tiffany received support from a behavioral specialist in their home. Tiffany's IEP goals focused on increasing multimodal communication (e.g., speech, signs, AAC, etc.) and receptive and expressive language.

Zach

Zach's parents reported he participated in weekly music therapy sessions at home and had a mental health case manager. Zach's IEP goals focused on multimodal communication (i.e. speech, signs, AAC, etc.) and functional communication replacements for his challenging behaviors.

Pamela

At the start of the study, Pamela had attended the school for children with ASD for just over 1 year. Pamela's IEP goals focused on following directions, transitioning between activities, and communicating using her AAC systems to request, make choices, and sequence grammatical structures to ask and answer questions.

Mark

Mark had been attending his current school for less than a year when he participated in this study. Mark's IEP goals focused on following directions, counting and sorting functional items, making choices given a range of options, and using his AAC system for communication. Mark's parents' reported two languages were spoken consistently at home (i.e., English and Spanish) and that Mark did not receive any therapeutic intervention at home.

Evan

Evan's parents did not report any interventions other than pharmacological being received outside the school environment. At the beginning of the study, Evan was taking four different medications to remediate symptoms associated with difficulties sleeping, aggression, gastroesophageal reflux disorder, and hypothyroidism. Evan's parents reported Evan is a cancer survivor and has a shunt in his brain as a result of a medulloblastoma. His IEP goals focused on increasing his multimodal communication (e.g., speech, signs, AAC, etc.) and receptive and expressive language skills.

Setting

All data collection sessions were conducted in the natural environment with the exception of Evan's. In this investigation, the natural environment was the child's typical classroom. Data collection sessions for Evan occurred in a separate room at his parent's and teachers' request. For the other five participants, the storybook reading activities during baseline, intervention, generalization, and maintenance phases were conducted within the classroom. The other students and teachers in the classroom followed their typical daily routine while the first author and the participant completed the storybook reading activities in

one area of the classroom. This was done so the children did not have to leave their everyday academic environment to participate in the storybook reading activity.

Materials

AAC Systems

Book-based communication displays were created for each book. Each communication display was designed on a tablet computer (i.e., Apple iPad). The iPad application Proloquo2Go was used during the baseline, intervention, generalization, and maintenance phases of this investigation. The same AAC systems were used with all of the children to maintain consistency in symbol representation, output, and layout. This allowed the researchers to control for variables that could have affected performance. Using Proloquo2Go, grid layouts were created for each of the selected storybooks. Each grid contained approximately 25–30 vocabulary items directly related to the plot of the storybook (see Appendix A). All vocabulary was represented using a digital image in the form of a photo of the vocabulary item taken directly from the pages of the storybook using the iPad's camera application.

The vocabulary items for each storybook were selected through a systematic process in which a member of the research team read the storybook and selected key vocabulary items for retell of the primary content using a minimum of two two-symbol messages for each two-page spread. A second member of the research team replicated this process. The selections were then compared until a final list of words was agreed upon. These vocabulary items were then grouped within each communication display as agents (i.e., storybook characters), actions (i.e., verbs performed by the characters), objects (i.e., things manipulated by the characters), or other. The *other* category was defined as feelings, interjections (e.g., *wow*, *cool*), and rote phrases (e.g., *turn the page*). Appendix A lists the vocabulary items from the grid displays for two storybooks used in this study. The agent symbols were outlined in blue, the action symbols were outlined in green, the object symbols were outlined in yellow, and the other symbols were outlined in orange. All grid layouts used during the study were made available to each child, his or her family, and teachers at the end of the study.

Two different iPads with Proloquo2Go were used throughout all phases of this research project. The iPads were alternated for every session with every participant so that the same books were not available in any two consecutive sessions. The child was free to choose the books he or she wanted to read from the choices available on the iPad being used for that session. In this way, the same book could not be read in every session. Further, at least two different books were read with each child in each data collection session across all phases of the study (i.e., baseline, intervention, generalization, and maintenance).

Books

The child's parents or caregivers and teacher were interviewed regarding the child's storybook preferences, and a list of storybooks and storybook characters that were motivating and familiar to each child was generated. From this list, the child with ASD chose storybooks via paired method or forced-choice preference assessment (Pace, Ivancic, Edwards, Iwata, & Page, 1985) to use during the language intervention sessions. Storybooks offered as options for the child included text, colored drawings, and characters reported to be motivating for the child. Each storybook was also at least 10 double-page spreads in length. In each session, the child with ASD had the choice of four preferred storybooks. There were two sets of four storybooks per child, so the same storybooks were not available two sessions in a row. New copies of the five storybooks read most frequently by each child were given to the child at the end of the study. The storybooks included reflected the level and type of storybook available to the participants in their classrooms, were storybooks the children were familiar with, and were similar to ones they engaged with in their homes.

Measures

The independent variable for the investigation was the systematic implementation of the LTM prompting procedure—to be specific, the added strategies of verbal prompting (asking a question), verbal cueing (request for production), and graphic modeling (device use). Although expectant delay (wait time) and verbal modeling (providing a verbal model of the target response) were also part of the LTM prompting procedures, they were not novel to the intervention phase. The dependent measure was the frequency of multisymbol messages (i.e., two or more symbols combined to communicate one message) communicated either after the presentation of a natural opportunity (i.e., natural cue) or after the least prompt, a short pause (i.e., expectant delay) during the storybook reading interaction using any symbolic modality (i.e., speech, AAC, sign language, or a combination). For this investigation, only multisymbol messages directly related to the storybook interaction were coded and graphed. Multisymbol messages related to the storybook interaction were operationalized as symbolic communication using any modality (i.e., speech, AAC, sign language, or a combination) that directed attention to the storybook or storybook interaction by using vocabulary associated with the storybook activity (adapted from Wetherby, Cain, Yonclas, & Walker, 1988). Examples of multisymbol messages related to the storybook content were actions of characters in the story (e.g., {JAY JAY SLEEP}), events occurring in the story (e.g., {JAR BUTTERFLY}), and vocabulary related to general storybook reading (e.g., {READ PLEASE}).

Procedure

Baseline

Prior to commencing baseline sessions, storybook preferences were determined for each child. During each baseline session, the iPad with the storybook-based communication

display was placed within view and reach of the child with ASD (see Appendix B). The child with ASD chose a storybook to read, and before beginning to read the storybook, the first author reviewed all of the vocabulary on the AAC display for that specific storybook with the child.

After reading each two-page spread, the principal investigator imposed an expectant delay (i.e., time delay) of 2 s to allow the child with ASD the opportunity to communicate about the storybook. Communication via any symbolic mode (e.g., iPad, signs, gestures, low-technology communication book) was accepted and responded to contingently. If the expectant delay passed and no communicative turn was taken, the first author commented on something that occurred in the two-page spread and imposed another 2 s delay to provide a second opportunity for the child with ASD to communicate something about the story. If the child with ASD communicated using a one-symbol message, the first author responded to the message and imposed another expectant delay. If the child communicated using a multisymbol message, the primary investigator praised the child and either rephrased or expanded the response to model a grammatically complete production. If the child with ASD did not say anything after the second expectant delay, the first author provided a spoken model using a combination of two vocabulary words available on the communication display. Modeling was verbal only during baseline sessions and did not involve use of the AAC system by the primary investigator. Two opportunities to communicate about the storybook were provided per double-page spread during the baseline sessions. Providing two opportunities to use the target skill (i.e., communicating using a two-symbol message) during the baseline sessions allowed the child with ASD to demonstrate his or her current level of ability prior to receiving the intervention.

There was a minimum of five baseline sessions for each child in the study to ensure stability of the child's performance and to account for any changes that might have been related to becoming familiar with the iPad as a mode of communication, the communication displays, or the format of the storybook reading interaction with the first author. All of the children had access to their personal AAC systems during the baseline sessions. These systems were placed on the table within reach of the child. Baseline sessions continued until there was limited variability (maximum variability of three multisymbol messages between the highest and lowest data point) with no positive trend in performance.

Intervention

The independent variable for the investigation was the systematic implementation of the LTM prompting procedure—to be specific, the added strategies of verbal prompting (asking a question, verbal cueing (request for production), and graphic modeling (device use). It should be noted that some components of the prompting structure (i.e., verbal models and expectant delay) were also in place during the baseline sessions. The third, fourth, and fifth levels of the LTM prompting hierarchy were completely novel from any communication strategy used during the baseline sessions. The combination and systematic progression of all five levels from expectant delay through the hand-over-hand prompt is also novel compared with the baseline sessions. The systematic implementation of prompting to elicit production of the targeted response was not part of the baseline procedures.

At the beginning of each intervention session, the child with ASD chose a storybook from the selection of preferred storybooks. Before reading the storybook, the primary investigator reviewed the vocabulary corresponding to the storybook with the participant by verbally labeling as well as selecting each item on the iPad. Following this review, the primary investigator began reading the storybook with the child. Following each double-page spread, the first author provided an expectant delay to offer the child an opportunity to initiate a symbolic turn about the book. The prompting procedures that followed the provision of the expectant delay are the LTM prompting procedures. During the intervention sessions, increasingly more intrusive prompts were provided until the child successfully produced a multisymbol message related to the storybook. If the child did not produce a multisymbol message after an expectant delay, a verbal prompt was given (e.g., *What's happening?*), and another expectant delay was used. If the child with ASD still did not communicate using a multisymbol message, the second level of prompting, a verbal prompt and verbal model, was provided, for example, *What's happening?* followed by *I see Jay Jay sleeping*. If the child still made no attempt to communicate using a multisymbol message about the story, the third level of prompting was implemented. This included a verbal prompt, verbal model, and graphic model (using the Proloquo2Go application on the iPad) to select the appropriate symbols {JAY JAY SLEEPING}. The fourth prompting level included all steps in Level 3 followed by the verbal cue *Now you try*. The final prompting level, hand-over-hand prompting, was only used after all previous prompting steps were attempted. For example, the final prompting level would include (a) [expectant delay], (b) *What do you see?* [expectant delay], (c) *I see Jay Jay sleeping* [expectant delay], (d) *I see Jay Jay sleeping* {JAY JAY SLEEPING} [expectant delay], (e) *Now you try* [expectant delay], (f) Hand-over hand assistance {JAY JAY SLEEPING}.

If the child with ASD produced a single-symbol message, the primary investigator responded to the message to encourage expansion. If this did not lead to production of a two-symbol message, the LTM prompting procedure was implemented. When the child with ASD produced a two-symbol message, the first author responded contingently on the basis of the content of the message (see Appendix B). For example, if the child with ASD communicated {JAY JAY FLY}, the feedback provided would be a positive, confirmatory statement, such as *That's right, Jay Jay is flying*. The teaching episode continued until the child produced the desired response, a two-symbol message related to the storybook being read. If a child tried to turn the page of the book before the end of a teaching procedure,

the interventionist informed the child that he or she needed to finish talking about the current page before moving to the next page. Once the teaching episode was completed through production of a related multisymbol message, the child was allowed to move forward to the next page of the storybook.

All of the children had access to their personal AAC systems during the intervention sessions. These systems were placed on the table within reach of the child. The intervention phase of the study followed the same 15-min structure as the baseline phase. After each two-page spread within the storybook, a teaching episode occurred, and the LTM prompting procedure was used to teach the production of multisymbol messages. At least two structured teaching episodes were provided to each child with ASD for every double-page spread read during the session. The intervention phase continued until a treatment effect was established. The treatment effect for this study was defined as production of multisymbol messages (as defined in the Measures section) that at least doubled the highest number produced during baseline sessions given only a natural opportunity (i.e., natural cue) or least prompt, a short pause (i.e., expectant delay) across three consecutive sessions. If the participant did not produce any multisymbol messages during the baseline sessions, a treatment effect was defined as production of at least two multisymbol messages given only a natural opportunity (i.e., natural cue) or least prompt, a short pause (i.e., expectant delay) across three consecutive sessions. Once either of these criteria for multisymbol message production were reached, the child moved to the generalization phase.

Generalization

Generalization probes were collected to determine if the participants were able to generalize the use of multisymbol messages to novel storybooks without the support of the LTM prompting procedure. All six participants participated in two or three generalization sessions. During these sessions, data were collected relative to the primary dependent variable to determine the carryover of use of multisymbol messages to the novel storybooks. During generalization sessions, the LTM prompting procedure was removed, and sessions were conducted using baseline phase procedures. Storybooks were considered novel if the participant had not read the storybook at all during either the baseline or intervention phases of the study. Generalization sessions occurred with the same interventionist (first author) and in the same environment (the child's classroom, with the exception of Evan) as baseline and intervention sessions. This phase provided information about whether or not the children with ASD continued to produce multisymbol messages during storybook reading interactions without prompting from the primary investigator.

Maintenance

Maintenance measures were collected at least 4 weeks after the completion of the generalization phase of the investigation. Each child with ASD participated in one, two, or three maintenance sessions, depending on availability and scheduling. The purpose of the maintenance sessions was to determine if the students with ASD retained acquisition of the target skill over an extended period of time. The procedures during the maintenance phase were identical to the procedures used during the intervention phase. The rationale for retaining the intervention procedures during this phase of the investigation was to be able to provide support and instruction to the students with ASD if use of the target skill was no longer apparent. If the student was not producing multisymbol messages, prompting by the primary investigator would be used to provide booster learning opportunities. If production of multisymbol messages was apparent, this would indicate the effect of the intervention was maintained at least over the short term.

Coding

Data were coded with regard to the number of symbols used (i.e., the length of the message) as well as the level of prompting required. All turns taken by the child were coded, but only messages related to the storybook being read, composed of more than one symbol, and communicated either after the presentation of a natural opportunity (i.e., natural cue) or after the least prompt, a short pause (i.e., expectant delay), were graphed and are analyzed in the Results section. A message was considered to be multisymbolic if the learner combined at least two symbols (e.g., speech, iPad, communication book, sign). For example, the child with ASD could communicate the two-symbol message *Jay Jay fly* using speech only; iPad symbols only; or any combination of speech, high-tech AAC, low-tech AAC, and/or sign language.

Reliability

Data Reliability

All sessions were videotaped to enhance coding accuracy and reliability of the data. A research assistant trained in the method of study but not naïve to the research question viewed and coded each session. To determine reliability of the coding, a second research assistant (also not naïve to the research question) coded a randomly selected segment of at least 20% of the data from each phase for every participant. Interobserver reliability was calculated using a point-by-point agreement ratio (Kazdin, 1982). After reliability percentages were determined and documented for reporting, disagreements were resolved through negotiation to ensure coding of the final data set was as accurate as possible. Reliability of data coding averaged across each phase and session per participant was 91% for Corey's data, 82% for Tiffany, 90% for Zach, 91% for Pamela, 88% for Mark, and 80% for Evan. On the basis of Kazdin's (1982) recommendations, 80% agreement between raters was considered sufficient for this investigation.

Procedural Reliability

A procedural standard for all phases of this intervention was developed (see Appendix B). The first author

trained two coders on all instructional procedures from the standard protocol. To be specific, coders assessed reliability on the first author's correct use of all levels of the LTM prompting hierarchy for two opportunities per two-page spread. The coders assessed if the prompts were provided in the appropriate order and according to the specified timing. The coders also checked to ensure that seating and positioning of the first author and the participant as well as the positioning of the AAC system were appropriate given the procedural standard. Training continued until the coders reached 90% compliance. To ensure procedures for the intervention were followed consistently, procedural reliability was calculated for approximately 20% of the data from all of the participants and all phases of the study. The mean procedural reliability across all participants and sessions was 94.21% (range: 90.68%–96.70%). This suggests the intervention procedures were followed consistently throughout the study with all of the participants.

Data Analysis

The data were graphed and visually inspected for changes in the trend and level of the data as well as the latency to treatment effect (Kazdin, 1982). The trend was analyzed to determine any change in directionality of the dependent variable after intervention when compared with baseline measures. The level of the data was calculated by determining the mean for the data for each phase. The mean levels for each phase were compared to determine the overall increase or decrease of the dependent measures upon introduction of the independent variable. Means were calculated by summing the total related multisymbol messages per phase and then dividing by the number of sessions in that phase (Kratochwill et al., 2010). Last, an analysis of latency indicated the number of intervention sessions to the onset of a treatment effect in the intervention phase of the investigation.

There are presently no agreed-upon methods or standards for effect size estimation when using a single-subject design (SSD). To date, several methods have been proposed. To estimate the effect size of the intervention in this study, an analysis of the percentage of nonoverlapping data (PND; Kazdin, 1982; Scruggs, Mastropieri, & Casto, 1987) was calculated. Much research has been done on the use of PND measures to estimate effect size in SSD. See Scruggs and Mastropieri (1998) for the most comprehensive review of this research as well as a discussion of the use of PND on interpreting data from SSD research.

Results

The number of multisymbol messages produced by each participant (as defined in the Measures section) is located in Figures 1 and 2. As can be observed, the intervention did affect the production of multisymbol messages for all of the participants.

Related Multisymbol Messages (Cohort A)

Corey, Tiffany, and Zach demonstrated an increase in multisymbol messages produced after the presentation of a natural opportunity (i.e., natural cue) or after the least prompt, a short pause (i.e., expectant delay), during the storybook reading interactions. This change occurred almost immediately upon introduction of the LTM prompting procedure (see Figure 1).

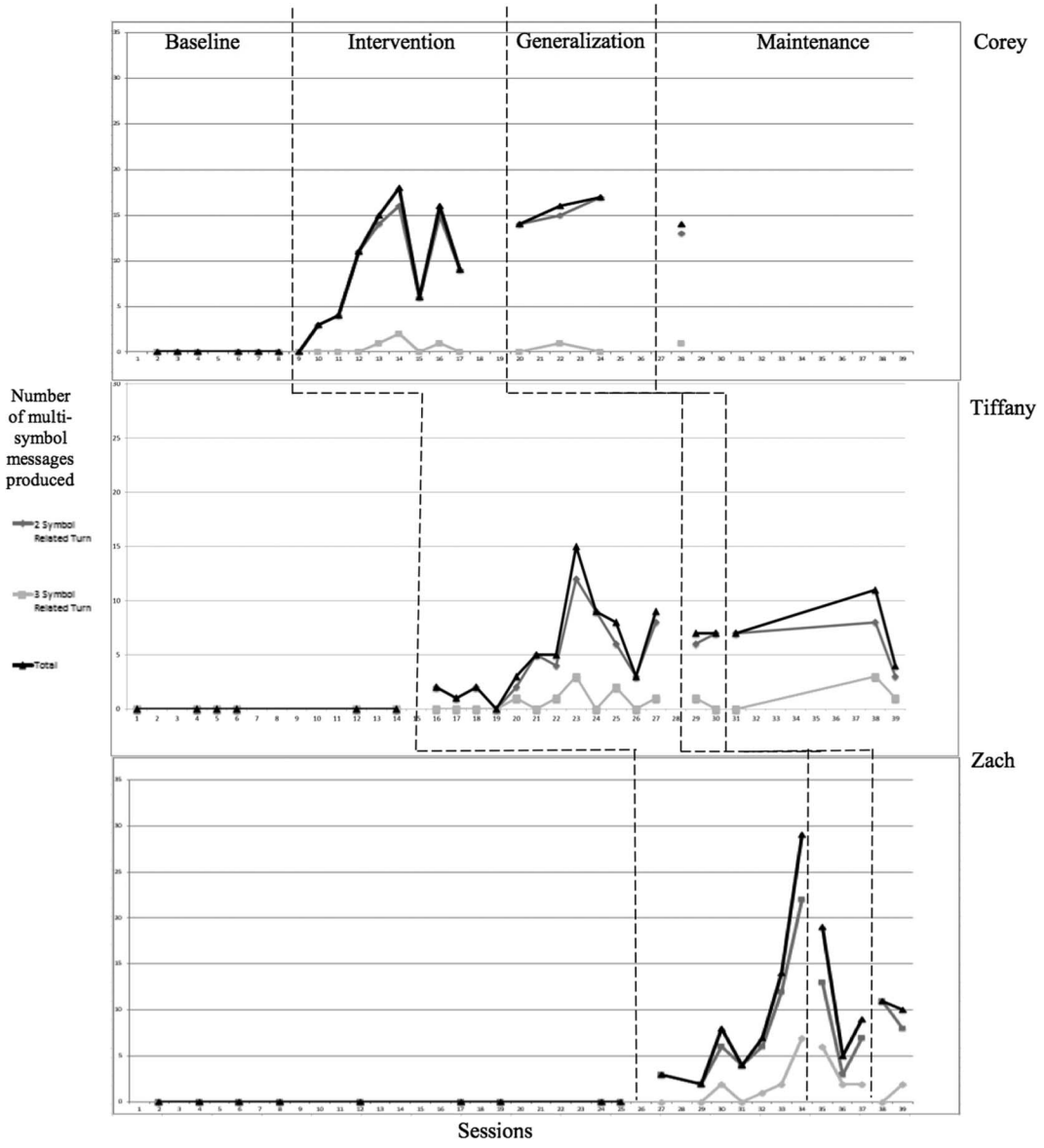
None of the participants in Cohort A produced any multisymbol messages during their baseline sessions. During intervention, Corey produced an average of 8.67 (range: 0–16) two-symbol messages and an average of .44 (range: 0–2) three-symbol messages per session. Tiffany produced an average of 4.5 (range: 0–12) two-symbol messages and an average of .67 (range: 0–3) three-symbol messages per session. Zach produced an average of 7.86 (range: 2–22) two-symbol messages and an average of 1.71 (range: 0–7) three-symbol messages per session (see Figure 1). Visual inspection of the trend of the data for Cohort A indicates an increasing trend in the number of multisymbol messages produced during intervention sessions. Last, visual inspection of the latency to treatment effect for Cohort A indicated that the onset of a treatment effect was observed in Intervention Session 2 for Corey, during Intervention Session 5 for Tiffany, and during Intervention Session 1 for Zach. This indicates the latency to the onset of a treatment effect was rapid but not immediate for all of the participants in Cohort A.

To assess the effect size of the results of the intervention for Cohort A, the PND was calculated for the production of two-symbol messages as well as the production of three-symbol messages. None of the participants in Cohort A produced any two-symbol or three-symbol messages during baseline. The PND for two-symbol messages for Corey was 89%, for Tiffany was 92%, and for Zach was 100%. The LTM prompting procedures were therefore effective (see Scruggs & Mastropieri, 1998) at teaching Cohort A to produce two-symbol messages. Further, all of the participants in Cohort A produced some three-symbol messages in some of their intervention sessions (i.e., Corey produced one to two in three intervention sessions; Tiffany produced one to three in three intervention sessions; and Zach produced one to seven in four intervention sessions), indicating this skill may be emerging (see Table 2).

Generalization Sessions

All of the participants in Cohort A participated in generalization sessions. Corey and Zach participated in three generalization sessions, and Tiffany took part in two generalization sessions. During these sessions Corey produced an average of 7.67 two-symbol messages (−1.0 message difference from mean intervention) and an average of 0.33 three-symbol messages (−0.11 from mean in intervention). Tiffany produced an average of 6.5 two-symbol messages (+2 from mean in intervention) and an average of 0.5 three-symbol messages (−0.17 from mean in intervention). Zach produced an average of 5.67 two-symbol

Figure 1. Intervention data for Cohort A.



messages (−2.19 from mean in intervention) and an average of 3.33 three-symbol turns (+1.62 from mean in intervention). These data indicate Cohort A was able to generalize the use of the targeted language skill when reading novel storybooks and without prompting, although, for the most part, at slightly lower levels than during intervention sessions.

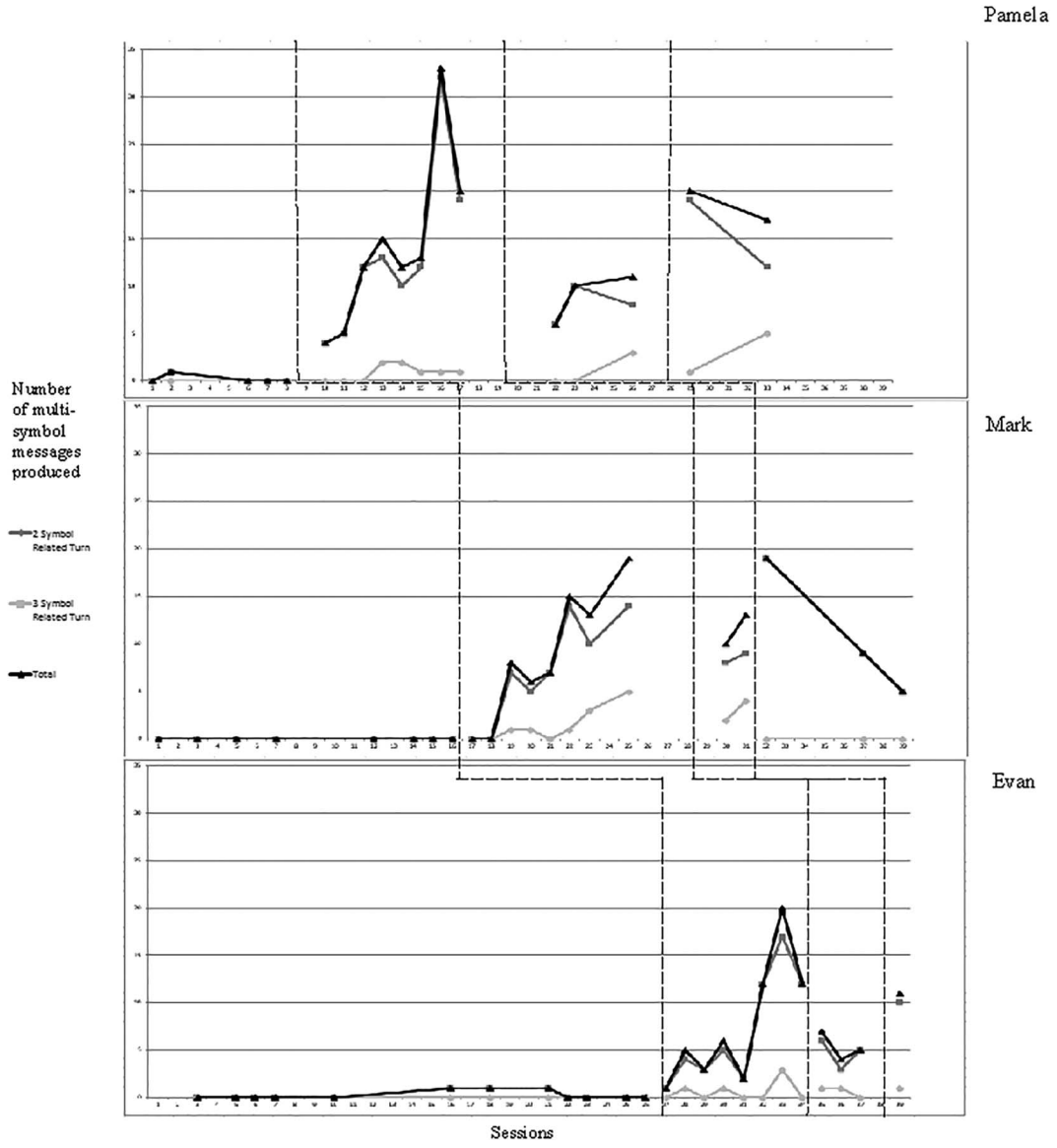
Maintenance Sessions

Cohort A also participated in maintenance sessions. Corey had one maintenance session 14 weeks postintervention. During this session, he produced 13 two-symbol messages (+4.33 from mean in intervention) and one three-symbol message (+0.56 from mean in intervention). Tiffany had three maintenance sessions 12, 19, and 26 weeks postintervention. During these sessions, she produced an average of six two-symbol messages (+1.5 from mean in intervention) and 1.33 three-symbol messages (+0.66 from mean in intervention). Zach had two maintenance sessions 6 and 9 weeks postintervention. During his maintenance sessions, he produced an average of 9.5 two-symbol messages (+1.64 from mean in intervention) and one three-symbol message (−0.71 from mean in intervention). Data from these sessions indicated that relative to intervention levels, the participants in Cohort A were able to maintain the intervention effects for weeks and months after the end of intervention (see Figure 1).

Related Multisymbol Messages (Cohort B)

Pamela, Mark, and Evan also demonstrated an increase in multisymbol messages produced after the occurrence of

Figure 2. Intervention data for Cohort B.



a natural opportunity (i.e., natural cue) or after the least prompt, a short pause (i.e., expectant delay). This change occurred almost immediately upon introduction of the LTM prompting procedure (see Figure 2) during storybook reading interactions.

During the baseline phase, Pamela and Evan produced an average of 0.2 and 0.25 two-symbol messages, respectively (range: 0–1) per session and produced no three-symbol related messages. Mark produced no multisymbol messages during his baseline sessions, similar to the participants in Cohort A. During intervention, Pamela produced an average of 13.38 (range: 4–32) two-symbol messages and an average of 0.86 (range: 0–2) three-symbol messages per session. Mark produced an average of 7.13 (range: 0–14) two-symbol messages and an average of 1.38 (range: 0–5) three-symbol messages per session. Evan produced an average of 7.00 (range: 1–17) two-symbol messages and an average of 0.63 (range: 0–3) three-symbol messages per session (see Figure 2). Visual inspection of the trend of Cohort B's data indicated an increasing trend in the number of multisymbol messages produced between baseline and intervention. Last, latency to treatment effect for Cohort B indicated the onset of a treatment effect was observed in Intervention Session 1 for Pamela, during Intervention Session 3 for Mark, and during Intervention Session 2 for Evan. Like Cohort A, this indicates the latency to the onset of a treatment effect was rapid but not immediate.

Table 2. Results of percentage of nonoverlapping data (PND) analysis.

PND	Corey	Tiffany	Zach	Pamela	Mark	Evan
Two-symbol comments	89%	92%	100%	100%	75%	100%
Effectiveness level for two-symbol comments	effective	highly effective	highly effective	highly effective	fairly effective	highly effective
Three-symbol comments	33%	42%	57%	63%	63%	38%
Effectiveness level for three-symbol comments	ineffective	ineffective	questionable effectiveness	questionable effectiveness	questionable effectiveness	ineffective

Note. See Scruggs and Mastropieri (1998) for a comprehensive review of the use of PND for interpreting data from single-subject design research.

To assess the effect size of the results of the intervention for Cohort B, the PND was calculated for the production of both two-symbol and three-symbol messages. Pamela produced only one two-symbol message during the five baseline sessions and produced a minimum of four two-symbol messages in each intervention session, indicating 100% PND. The PND analysis for Mark resulted in 75% nonoverlapping data and 100% for Evan. Mark did not produce any two-symbol messages during the first two intervention sessions but produced at least five in the other six intervention sessions. These PND scores indicate the LTM prompting procedure was effective (see Scruggs et al., 1987) at teaching Cohort B to produce two-symbol messages during storybook reading interactions. The LTM prompting procedure was ineffective at teaching three-symbol messages; however, all of the participants in Cohort B produced some three-symbol messages in some of their intervention sessions (see Table 2).

Generalization Sessions

Pamela and Evan took part in three generalization sessions, and Mark participated in two generalization sessions. During generalization, Pamela produced an average of eight two-symbol messages (−5.38 from mean in intervention) and an average of one three-symbol message (+0.14 from mean in intervention); Mark produced an average of 8.5 two-symbol messages (+1.37 from mean in intervention) and an average of three three-symbol messages (+1.62 from mean in intervention); and Evan produced an average of 4.67 two-symbol messages (−2.33 from mean in intervention) and took an average of 0.67 three-symbol turns (+0.04 from mean in intervention). For all of the participants in Cohort B, the number of multisymbol messages produced in generalization sessions was fewer than the number produced during intervention sessions. Multisymbol messages were used by all of the participants but not as frequently as when the LTM prompting procedure was in use.

Maintenance Sessions

Pamela had two maintenance sessions 14 and 23 weeks postintervention. During these sessions, she produced an average of 15.50 two-symbol messages (+2.12 from mean in intervention) and three three-symbol messages (+2.14 from mean in intervention). Mark had three maintenance sessions 26, 28, and 32 weeks postintervention. His average production of two-symbol messages was 11 per session (+3.87 from mean in intervention) and zero three-symbol messages (−1.38 from mean in intervention). Evan had one maintenance session 9 weeks postintervention. During this session, he produced 10 two-symbol messages (+3.00 from mean in intervention) and one three-symbol message (+0.37 from mean in intervention). Data from these sessions suggest Cohort B maintained the use of two-symbol messages and, in some instances, increased use of multisymbol messages for at least 2 and up to 8 months after the end of intervention (Figure 2).

Discussion

The results of this study indicate the LTM prompting procedure was effective for teaching these school-age children with ASD to use multisymbol messages during storybook reading. None of the six participants produced multisymbol messages during his or her baseline sessions (Pamela produced only one multisymbol message during one baseline session). All six of the children with ASD used two-symbol messages in most of their intervention sessions (see Figures 1 and 2). Further, all six children produced some three-symbol messages during some of their intervention sessions.

Evidence of the efficacy of this intervention is further apparent in the results of the effect size analysis (i.e., PND) for all participants. All participants demonstrated effects that were between 75% and 100% nonoverlapping with their performance during baseline sessions for two-symbol messages, the dependent variable. The changes observed in the multisymbol messages produced by the children with ASD from their baseline sessions to their intervention sessions was systematically observed on the basis of the introduction of the LTM prompting procedure. Combined with the results of the visual analysis of trend, level, and latency to treatment effect in production of multisymbol messages, the effectiveness of the LTM prompting procedure in teaching this skill to these children with ASD is convincing (see Table 2).

The results of this project support the utility of the LTM prompting procedure for teaching the use of

multisymbol messages to children with ASD who use AAC. This outcome recommendation is important to the ASD community because intervention with school-age children with ASD can be complex. There is limited evidence for LTM prompting procedures for teaching language skills to school-age children with ASD who use AAC, and there is no research on the use of LTM prompting procedures to promote communication for expressing multisymbol messages.

The results of the current study provide new and needed evidence of an intervention option for teaching language and communication to children with ASD who require AAC to meet their daily communication needs. This population has recently been recognized by the National Institutes of Health as a population that is severely understudied. Evidence of effective interventions for teaching language and communication to children with ASD who require AAC will help clinicians and teachers make more informed intervention decisions for children with ASD in schools.

Last, this study provides some information about the durable effects (Kasari & Smith, 2013) of the LTM prompting procedure. Maintenance sessions were completed with all six of the participants, and all but one (i.e., Mark) maintained his or her rates of multisymbol messages several months postintervention. The mean number of months the last maintenance session was completed after the termination of the intervention sessions was 3.8 months (range: 2–8 months). The results from the current investigation indicate, then, that the effects observed during intervention were durable and continued to be within each child's repertoire of communicative skills even months after instruction had ended.

Clinical Implications

The current study suggests the LTM prompting procedure can be successfully used as an intervention technique to promote multisymbol messages in children with ASD who use AAC to communicate during storybook reading interactions. Speech-language pathologists and educators may potentially use this LTM prompting procedure with children who are similar to the children who participated in this investigation to increase expressive communication through the use of an AAC system. The increases observed in the communicative productions of the children in this study are exciting and allowed the school-age children with ASD to interact more effectively in an academically valued activity within one of their prominent daily environments, their classroom.

From our experience, the LTM prompting procedure was fairly simple to implement with the children with ASD and use in the classroom context. Although this has not been tested empirically, it seems reasonable that a school-based speech-language pathologist could implement this intervention approach with many different students on his or her caseload to teach a variety of different skills. It seems this intervention approach could also be used by teachers to create consistency across instructional contexts. Consistency in instructional approaches across contexts may be beneficial for children with ASD who use AAC who may rely on routine and thrive in situations in which expectations are clear and constant.

Limitations

Although the results of this study appear noteworthy, there are limitations that should be considered. First, only one interventionist delivered the LTM prompting procedure throughout the study. This may lead to concerns about the participants generalizing the learned communication skill to interactions with other communication partners. Further, because the children with ASD could pick any storybook they wanted to read for each session, often the same or similar storybooks were chosen across sessions. It is not possible to know what the participants may have learned or remembered from previous readings of a book. For example, it is possible that models from the clinician and/or conversations about the story from previous sessions influenced the messages produced in subsequent sessions. However, the consistency of the increases in the use of multisymbol messages across all of the research participants should dampen this concern. It is also possible that some of the treatment effects were due, at least in part, to strategies in place during baseline. Although these strategies alone did not result in changes to the multisymbol message production by the participants, it is possible some learning was occurring during baseline sessions.

In addition, social validity measures were not collected; therefore, it is not known if the classroom teachers, aides, parents of the participants, or the participants themselves felt this intervention was valuable and/or successful at teaching new skills. It is also important to note the intervention could potentially have been more beneficial, and more socially valid, to the participants if they had been able to use their own AAC device rather than the standardized communication boards on the iPad. Last, it should be noted that generalization was only tracked within the context of reading novel storybooks during a similar shared storybook reading activity. It is not known if the results from the intervention would generalize to other contexts. These limitations should be addressed in future research studies in this area of inquiry.

Summary

Developing communication continues to be a persistent challenge and is one of the most common characteristics among individuals within the ASD population (Lord et al., 2004). Despite this, when given support, children with ASD who use AAC can learn and develop new and more sophisticated communication skills. The results of the current investigation suggest using this LTM prompting procedure during AAC intervention was efficacious

when targeting increasing the production of multisymbol messages.

Acknowledgments

This research was supported by a grant from the Organization for Autism Research. We are thankful for this support because the research would not have been possible without it. We also thank all of the participants, their families, as well as the administration and staff at The Vista School in Hershey, Pennsylvania, for their roles in making this research possible.

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Appendix A

Sample Book Vocabulary from iPad Displays

Jay Jay the Jet Plane: Jay Jay Earns His Wings
Agents: Big Jake, Brenda, Captain Wentworth, Caterpillar, Herky, Jay Jay, Butterfly
Actions: fly, hatch, practice, sleep, stuck, teach
Objects: cocoon, flowers, home, Sandy Landing, wings
Other: happy, fun, oh no!, scared, pretty, proud, sad, terrible, turn the page, wow!, yay!
Sid the Science Kid: Why Did My Ice Pop Melt?
Agents: Sid, Mom, Gabriela, May, Gerald, Teacher Susie, Grandma, Dad
Actions: ask, eat, freeze, look, make, melt, see, show, talk, wait, question
Objects: fruit, freezer, ice, ice pop, puddle, snack, water
Other: idea, happy, ready, sad, turn the page

Appendix B (p. 1 of 3)

Procedural Standard

Session type	Goals	Content
I. Baseline phase		
Baseline sessions (five minimum; 15 min each)	Obtain preintervention measurements of participant's use of multisymbol comments	Setup • Researcher sets up camcorder so that child, researcher, and iPad are all within view or, if possible, research assistant films the interaction without use of a tripod • iPad available to and facing participant ○ Child sits at 90° angle from the researcher with the iPad in front of the researcher facing the child or ○ Child and the researcher sit side-by-side with the iPad facing both and within reach of the child ○ Researcher reviews all vocabulary on the iPad related to the book verbally and by selecting each item on the iPad prior to reading for every book Provide spoken models during reading • Provide two spoken models per double-page spread using vocabulary that is represented graphically on the iPad • If the child makes a symbolic comment, ○ Pause for at least 2 s to ensure child has completed his or her turn ○ Provide spoken model • Provide a spoken model that reflects the symbolic comment for each symbolic turn that the child completes, for example, ○ Child: {SPONGE BOB} on iPad ○ Researcher: *Sponge Bob gives Sqidward a present* • After the spoken model, ○ Pause to provide the child with an opportunity to communicate using expectant delay ○ Length of pause equals (a) the mean of each child's turn transfer time (more than 10 turns) or (b) 2 s, whichever is longer • If the child does not make a symbolic comment after the expectant delay, ○ Provide another spoken model ○ Provide another expectant delay • Repeat, providing at least two spoken models per double-page spread using the vocabulary that is represented graphically on the iPad Length of reading sessions • Each reading session is 15 min in length Off-task behaviors • Respond to the child without providing a model if ○ Child is hurting someone ○ Child is causing damage to the materials ○ Child is communicating about things outside of the book being read
II. Intervention phase		
Intervention sessions (five minimum; 15 min each)	Teach participant to express multisymbol comments using iPad and LTM prompting procedures	Setup • Researcher sets up camcorder so that child, researcher, and iPad are all within view • iPad should be available to and facing participant ○ Child sits at 90° angle from the researcher with the iPad in front of the researcher facing the child or ○ Child and researcher sit side-by-side with the iPad facing both and within reach of the child
	Operational definition of target behavior	• For each page of a story read during a session, the child will produce a two-or-more-symbol comment related to the book using a symbolic form of communication (i.e., speech, sign language, iPad/AAC system, picture-based system) Provide learning opportunities using LTM prompting • Child selects book from available options • Review all vocabulary on the iPad grid for the chosen book verbally and by selecting each item on the iPad prior to reading for every book

(*table continues*)

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Procedural Standard

- Read the title of the book and show the cover to the child
- Pause to allow the child an opportunity to comment (provide an expectant delay)
  - Length of pause equals (a) the mean of each child's turn transfer time (more than 10 turns) or (b) 2 s, whichever is longer
- If the child initiates using a two-or-more-symbol comment at the beginning of the book,
  - Confirm the child's response as correct
    - *Great! You're right, Sponge Bob is kicking*
  - Provide a spoken model that recasts or expands the child's symbolic message
    - *Sponge Bob is kicking the soccer ball into the goal*
  - Move on to provide learning opportunities using LTM prompting procedures during reading
- If the child initiates with a one-symbol turn at the beginning of the book or says nothing,
    - {SPONGE BOB} on AAC device
  - Level 1: Provide a verbal prompt:
    - *What is Sponge Bob doing?*
  - If the child then produces a two or more–symbol comment,
    - Confirm the child's response as correct
      - *Great! You're right, Sponge Bob is kicking*
    - Provide a spoken model that recasts or expands the child's symbolic message
      - *Sponge Bob is kicking the soccer ball into the goal*
    - Move on to provide learning opportunities using LTM prompting procedures during reading
- If the child still does or says nothing,
  - Level 2: Provide verbal prompt and a verbal model:
    - *What is Sponge Bob doing? Sponge Bob kicking.*
  - If the child then produces a two or more–symbol comment,
    - Confirm the child's response as correct
      - *Great! You're right, Sponge Bob is kicking*
    - Provide a spoken model that recasts or expands the child's symbolic message
      - *Sponge Bob is kicking the soccer ball into the goal*
    - Move on to provide learning opportunities using LTM prompting procedures during reading
- If the child still does or says nothing,
  - Level 3: Provide verbal prompt, verbal model, and a graphic model:
    - {SPONGE BOB Sponge Bob} {KICK kicking} *Sponge Bob kicking*
  - If the child then produces a two or more–symbol comment,
    - Confirm the child's response as correct
      - *Great! You're right, Sponge Bob is kicking*
    - Provide a spoken model that recasts or expands the child's symbolic message
      - *Sponge Bob is kicking the soccer ball into the goal*
    - Move on to provide learning opportunities using LTM prompting procedures during reading
- If the child still does or says nothing,
  - Level 4: Provide verbal prompt, verbal model, graphic model, and verbal cue:
    - {SPONGE BOB Sponge Bob} {KICK kicking} *Sponge Bob kicking, you try it*
  - If the child then produces a two or more–symbol comment,
    - Confirm the child's response as correct
      - *Great! You're right, Sponge Bob is kicking*
    - Provide a spoken model that recasts or expands the child's symbolic message
      - *Sponge Bob is kicking the soccer ball into the goal*
    - Move on to provide learning opportunities using LTM prompting procedures during reading

(*table continues*)

Appendix B (p. 3 of 3)

Procedural Standard

		• If the child still does or says nothing, ○ Level 5: Provide a hand-over-hand response to the original verbal prompt ○ Confirm the child's response as correct ■ *Great! You're right, Sponge Bob is kicking* ○ Provide a spoken model that recasts or expands the child's symbolic message ■ *Sponge Bob is kicking the soccer ball into the goal* ○ Move on to provide learning opportunities using LTM prompting procedures during reading Provide LTM prompting procedures during reading • Provide two learning opportunities using LTM prompting procedures per double-page spread • If the child initiates a two-or-more-symbol comment at the presentation of a natural opportunity (reading text + expectant delay), ○ Confirm the child's response as correct ■ *Great! You're right, Sponge Bob is kicking* ○ Provide a spoken model that recasts or expands the child's symbolic message ■ *Sponge Bob is kicking the soccer ball into the goal* • If the child initiates a one-symbol comment at the presentation of a natural opportunity (reading text + expectant delay) or says nothing, ■ {SPONGE BOB} on AAC device ○ Proceed using the LTM prompting procedures outlined above ■ Level 1: Provide a verbal prompt ■ Level 2: Provide verbal prompt and a verbal model ■ Level 3: Provide verbal prompt, verbal model, and a graphic model ■ Level 4: Provide verbal prompt, verbal model, graphic model, and verbal cue ■ Level 5: Provide a hand-over-hand response to the original verbal prompt
III. Generalization without intervention		
Generalization without Intervention (two minimum; 15 min each)	Determine if participant generalized use of multisymbol comments to new reading contexts without the benefit of LTM prompting	• Procedures will be identical to baseline sessions guidelines • Novel books—those not read during baseline or intervention sessions—will be read during the generalization sessions
IV. Maintenance sessions		
Maintenance sessions (one to three sessions; 15 min each)	Determine if participant continues to produce multisymbol comments after instruction ceases	• Procedures will be identical to intervention session guidelines • The same books that are used for intervention sessions will be used • Conduct booster sessions if criterion for number of multisymbol comments produced is not met

Note. LTM = least-to-most.