EMPOWERING CHILDREN WITH COMPLEX COMMUNICATION NEEDS TO USE
IPAD BASED AAC DURING SHARED STORYBOOK READING

A Dissertation in
Special Education
by
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ABSTRACT

Drawing on the importance of language input and interaction for language acquisition, a single subject multiple baseline design was conducted to assess the impact of the ModelER (Model, Encourage, Respond) for Read and Talk intervention on the communication performance of preschool aged children with autism and intellectual disabilities who require augmentative and alternative communication (AAC). Children and educational assistants were provided with two Apple iPads running the Proloquo2Go AAC application and engaged in 10-min shared storybook reading experiences. The frequency and modality of child communication turns and educational assistant instructional performance were both assessed. Educational assistants received a ModelER training that consisted of one-to-one instruction combined with eLearning experiences on the iPad and bug-in-the-ear tutoring during the shared storybook reading. Results indicated large gains in child communicative turns using the iPad and in educational assistant instructional performance. The results, implications for the AAC field, and future research are discussed.
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Chapter 1

Introduction

An estimated 1.3% of the U.S. population, nearly four million individuals, and approximately 0.2 to 0.6% of the school-age population worldwide, have complex communication needs (CCN) (Beukelman & Mirenda, 2013; Blackstone, 1990; U.S. Department of Education, National Center for Education Statistics, 2012). While most people have the ability to meet daily communication needs using speech, those with CCN require alternative methods for language acquisition and communication. For children with CCN, language acquisition can be achieved through access to augmentative and alternative communication (AAC). AAC involves the use of multiple modalities to communicate, such as speech, vocalizations, signs, gestures, writing, pictures, and speech-generating devices (SGDs) (Beukelman & Mirenda, 2013). Access to AAC provides children with CCN opportunities to build language and literacy skills, which is important for increasing their probability of academic success (Adams, 1990). Building language and literacy skills is especially important in the context of school-based initiatives such as the Common Core State Standards for English language arts, which also includes literacy in history/social studies, science, and technical subjects (2010).

Over the past four years, there has been increased interest from families (Rummel-Hudson, 2009), teachers (Flores et al., 2012; Sennott & Bowker, 2009), and the AAC field (Light & McNaughton, 2012) in providing children with CCN with SGDs comprised of new mobile technologies (e.g., Apple's iPad), with AAC software. Light and Drager (2007) highlighted the importance of using popular technologies to enhance the appeal and functions of AAC systems. Light (1997), however, cautioned that the tools and modalities developed by the field of AAC are only one component. Communication and AAC tools together enable social interactions that
foster the important social purposes of communication such as (a) expressing needs and wants, (b) feeling social closeness, (c) sharing information, (d) fulfilling established conventions of social etiquette, and (e) communicating with oneself in an internal dialogue (Light, 1988; Beukelman & Mirenda, 2013).

The goal of AAC, described by Porter (2007), is to give people the ability to meet socially valued daily language needs efficiently, specifically, intelligibly, and independently. This communicative competence is not necessarily an inherent trait, but something that must be learned and scaffolded (Light, 1997). Communicative competence can be organized into linguistic, operational, social, and strategic domains (Light, 1989). The challenge for the field of AAC is to develop interventions that scaffold communicative competence for children who are acquiring language and using AAC. In considering the linguistic domain of communicative competence, knowledge of typical language development can be a guiding force in supporting children who are learning to acquire language with AAC (Gerber & Kraat, 1992; Light, 1997; Paul, 1997).

**Language development and AAC**

In typical language development, language input is one of the foundations of the language acquisition process (Gallway & Richards, 1994; Gerkin, 2008; Hart & Risley, 1995; Snow & Ferguson, 1978; Tomasello, 2003). Over the first four years of life, children who learn to use speech typically experience a massive amount of language input, approximately 25 million words (range=8-50 million words) (Hart & Risley, 1995). This spoken language input frequently occurs during social interactions where the adult is engaging with the child in a shared activity, directing the attention of the child, and introducing new vocabulary and language structures. Tomasello (2003) described these interactions as the driving force for language development. The strong foundation for the importance of language input presented in the spoken language acquisition literature is also found in sign language acquisition literature (Bavelier, Newport &
Supalla, 2003; Newport & Supalla, 2000), which indicates that given sign language input and interaction, children can develop complex language abilities using sign.

In comparison, the language acquisition process for children with CCN is more challenging in part due to their inability to communicate expressively with the same modality (i.e., speech) used in their environment during social interactions (Beukelman & Mirenda, 2013; Romsiki, Sevcik, & Adamson, 1997; Smith & Grove, 2003). This phenomenon of mismatched input to output, in which children with CCN mostly hear speech during social interactions, yet use AAC to communicate, has been described as an asynchrony of input to output (Smith & Grove, 2003). In response to the potential challenges posed by this asynchrony during communication interactions, a number of interventions have been proposed. These interventions provide rich language input to individuals using AAC expressively by arranging the natural environment to provide frequent incidents for teaching language and have roots in approaches primarily developed for children using speech, such as incidental teaching approaches (Hart & Risley, 1975; Warren & Kaiser, 1986), milieu-based teaching approaches (Hancock & Kaiser, 2006; Warren & Yoder, 1997), pivotal response training (Koegel & Koegel, 2006), and various Hannen Programs (Girolametto, Weitzman & Greenberg, 2006). For children with CCN, language input in the form of AAC modeling is an important component of effective AAC interventions (Goosens, Crain, & Elder, 1992; Light, 1997b, Romsiki & Sevcik, 1996; Smith & Grove, 2003).

**AAC modeling meta-analysis**

In a recent meta-analysis of interventions that included *AAC modeling* as a primary component (Sennott, Light, & McNaughton, 2012, See Appendix A), the foundational importance of language input in the language acquisition process was examined (Gerkin, 2008; Hart & Risley, 1995). The term AAC modeling was defined as: (1) engaging in the context of a naturalistic communication interaction, and (2) modeling of aided AAC in which the
communication partner (e.g., a parent, teacher), as they are speaking, points to or in some way activates vocabulary items in the child’s AAC system (or a copy of the child’s system). Table 1 of the meta-analysis includes an overview of the 17 intervention studies that included AAC modeling as a primary independent variable (see Appendix A). Across the 17 studies, many different formats for intervention and names for intervention packages were represented. The two earliest represented were Aided Language Stimulation (ALgS) (Goosens, 1989) and the System for Augmenting Language’s (SAL) augmented input (Romski & Sevcik, 1996). Other AAC modeling interventions included natural aided language (Cañiero, 2001), aided language modeling (Drager et al., 2006), and aided AAC modeling (Binger & Light, 2007).

Overall, meta-analysis results included 9 single-subject studies representing 31 participants and 70 replications. The included studies targeted preschool aged children less than 6 years of age \( (n=21) \) and school aged children ages 6 to 12 \( (n=10) \). A range of disabilities was represented including cerebral palsy, Down syndrome, autism, childhood apraxia of speech, and other developmental disabilities.

The meta-analysis results pointed to meaningful linguistic gains across four domain components including pragmatics, semantics, syntax, and morphology. When interpreting the results, authors noted that all of the studies included package interventions that included AAC modeling as a primary component, but also included various other related components. Six of the nine intervention packages specifically incorporated and operationalized additional components such as question asking, time delay, and responsive language strategies. Due to the packaged nature of these interventions it was difficult to determine the independent variable component responsible for change. Overall, the results were consistently positive. For example, the two studies targeting pragmatics each demonstrated a large gain in the frequency of child communication turns in the context of shared storybook reading (Binger & Hasham, 2010; Rosa-Lugo & Kent-Walsh, 2008). The three studies targeting semantics demonstrated gains in
vocabulary identification in the contexts of play, arts and crafts, and shared storybook reading (Dada & Alant, 2009; Drager et al., 2006; Harris & Reichle, 2004). The three studies targeting syntax demonstrated considerable gains in the frequency of multi-symbol turns taken by the children in the context of play (Binger & Light, 2007) and shared storybook reading (Binger et al., 2008; Binger et al., 2010). The single morphology study demonstrated sizeable gains in target morphology structures (Binger et al., 2011) in the context of shared storybook reading. For participant-level and study-level effect sizes, see Appendix A.

**ModelER for Read and Talk**

The meta-analysis yielded evidence to support the combination of three promising intervention variables: AAC modeling, time delay, and responsive language strategies (Sennott et al., 2012). Building upon AAC intervention literature, these variables were packaged into a more general intervention, *ModelER* (Model, Encourage, Respond) for Read and Talk. In this intervention, educational assistants (EAs) are trained to work flexibly with children with CCN in the context of shared storybook reading.

ModelER represents (a) model - modeling AAC use (Sennott et al., 2012); (b) encourage - encouraging communication through time delay (e.g. Halle, Baer, & Spradlin, 1981); and (c) respond - responding to child communication attempts through AAC recasting (Camarata & Nelson, 2006; Nelson et al., 1996; Harwood, Warren, & Yoder, 2003). AAC modeling is the foundation of the intervention and is designed to provide the child a model of language use (pragmatics), content (semantics), and form (syntax and morphology). Encouragement to communicate, in the form of a time delay, provides opportunities for the child to initiate a communication turn and serves to demonstrate the communication partner is waiting and interested. As a support to the child’s communication attempts, the respond component focuses on AAC recasting the child’s utterance by using AAC to (a) repeat a portion of their utterance, and (b) correct or expand the utterance. AAC recasting is designed to (a) maintain the basic
meaning of what the child said, and (b) focuses on expanding the length or complexity of the utterance while keeping the conversation turns flowing (Nelson et al., 1996). Because recasts are based on something the child just communicated, AAC recasting is designed to assist the child in attending to the more advanced structures being modeled. AAC recasting can be thought of as a specific variant of AAC modeling.

The Read and Talk component of the intervention is adapted from variants of shared storybook reading interventions, such as dialogic reading (Dale et al., 1996; Whitehurst & Lonigan, 1998), special education specific approaches (Ezell & Justice, 2005), and AAC specific approaches (Bedroisian, 1999; Sennott, Light, & McNaughton, 2012; Stephenson, 2009). Read and Talk refers to reading a book and talking about it through making comments or asking questions. The Read and Talk components create a learning environment that would be typical of an early childhood shared reading context. When combined, ModelER for Read and Talk is designed to make dialogic reading accessible for children with CCN who are learning to use AAC and promotes individualized, language rich multi-turn communication sequences.

**Pilot study**

The results of a preliminary study (Sennott & Mason, 2012) indicated that ModelER for Read and Talk training promoted increased EA intervention skills such as using various types of AAC models and time delays, and supported sizeable student gains in communication turns using AAC and speech (see Appendix B for study). The two children in the preliminary case study Bobby, aged-3-years-old, and Amanda, aged-5-years-old, had intellectual disabilities, were placed in a classroom for children with autism, and were in the process of autism diagnostic evaluation. During their classroom programming, the children and their EAs engaged in 10-min repeated readings. The child-EA dyad used a set of three storybooks and an iPad to access symbol based AAC vocabulary displays containing a mix of high frequency and book specific vocabulary.
During the intervention phase of the preliminary study, the EAs engaged in a ModelER for Read and Talk training session. Then during subsequent intervention reading sessions the researcher provided in-session tutoring while seated at the table with the dyad. Each child-EA dyad in the preliminary study displayed different communication profiles. At baseline, Bobby's EA was not yet performing AAC models and was demonstrating a low mean of 6 time delays. During intervention Bobby's EA increased to a mean of 26.6 total AAC models during intervention and 18.8 time delays. From baseline to intervention, Bobby demonstrated a large gain in AAC and speech turns, with a mean difference of 29.9 iPad AAC turns and 20.1 speech turns.

By comparison, Amanda's EA was already performing a mean of 15 AAC models and 19.1 time delays at baseline and increased to a mean of 40.5 AAC models and 30.8 time delays during intervention, with gains maintained during post-intervention. Because Amanda was taking a high level of communication turns at baseline, she made only modest gains in iPad AAC turns. As reported by her EA, Amanda began producing multi-symbol AAC utterances for the first time in her life during intervention.

**Current study**

Analysis of the preliminary study indicated that training, in-session tutoring, and intervention materials needed further development. Therefore, the training system was enhanced to include an eLearning component using the iPad as a platform. eLearning provided additional interaction and simulated practice experience for the EA during training. To provide less invasive coaching, and to provide greater experimental control over potential effects from having the coach present at the table, in-session coaching was changed to a remotely delivered system using a bug-in-the-ear feedback system (i.e. the EA receives instructional feedback through a Bluetooth headset from a coach in another room). To control for effects of repeated reading, the closed set
of books used for repeated shared storybook reading in the preliminary study was replaced with two novel books for each reading session in the current study.

**Research importance and research question**

As indicated in the literature on (a) general language acquisition and the importance of language input (Gallway & Richards, 1994; Gerkin, 2008; Hart & Risley, 1995; Snow & Ferguson, 1978), (b) sign language (Bavelier, Newport & Supalla, 2003; Newport & Supalla, 2000), and (c) AAC (Goosens, Crain, & Elder, 1992; Light, 1997b; Romski & Sevcik, 1996; Sennott et al., 2012; Smith & Grove, 2003), interventions that include AAC modeling are deserving of study. Within the overarching goal of systematically working to identify effective special education practices (Horner et al., 2005), the current study sought to evaluate the impact of ModelER for Read and Talk intervention on communication performance by measuring frequency of communication turns.

The purpose of the present study was to demonstrate the effects of the ModelER for Read and Talk intervention package on child communication performance and EA instructional performance in the context of shared storybook reading. Given meta-analysis and pilot study findings, ModelER for Read and Talk was expected to increase the number of child communication turns and improve EA instructional performance during shared storybook reading. The following questions were asked:

1. What is the impact of the EA’s implementation of ModelER for Read and Talk on the child’s communication performance measured by frequency of total communication turns and turn modality: iPad AAC, speech, sign language, vocalization, and gesture?
2. What is the impact of the ModelER for Read and Talk intervention package on EA instructional performance of model steps (AAC models), encourage steps (time delays), and respond steps (AAC recasts) during the shared storybook reading sessions?
3. How do the EAs perceive the ModelER for Read and Talk intervention package?
Chapter 2

Method

Setting

The study took place in two early childhood education centers in a university town located in the Northeast. Both centers had pre-school classrooms designed to serve children with disabilities. One of the centers had an inclusive classroom designed to support children with low and high incidence disabilities. The other center had a classroom designed for children with autism spectrum disorders. Both classrooms included a low adult-to-child ratio (one adult to two children) and a highly structured sequence of academic and therapeutic activities that focused on goals in the children’s individualized education plans. To avoid untrained educational assistant (EA) participants observing the intervention in action, shared storybook reading sessions occurred in small break-out rooms adjacent to classrooms.

Participants

Following approval of the study by the university Internal Review Board (IRB), local preschools were contacted (See Appendix C for IRB approval letter, Appendix D for parent and Appendix E for EA consent forms). Teachers and speech language pathologists (SLPs) nominated potential students and EAs for inclusion in the study. The parents of nominated children were contacted by telephone and the parent consent form was signed at home or at the school. EA consent forms were signed at the school. Child assent was obtained during the initial book reading session (see Appendix F for full procedure and form).

Child inclusion criteria were adapted from recommendations described in Bedrosian (1999) and the ImpAACt series of studies (Kent-Walsh, Binger and colleagues) for shared storybook reading interventions. Criteria included that: (a) the child be between 3- and 5-years-
old, and (b) there be a severe speech impairment as evidenced by no intelligible speech production or a repertoire of fewer than 25 intelligible spoken words. The rationale for targeting children 3 to 5-years-old was based on the importance of early communication development (Tomasello, 2003). Preschool children who speak a small number of intelligible words require intervention, one that assists them in developing an AAC system for communication at home, in school, and in the community.

The inclusion criteria for each EA who worked with a child included that the EA: (a) assisted the child with tasks during school regularly (typically at least 3x per week); (b) had previously worked with the child for longer than 4 weeks; and (C) had not demonstrated high levels of the primary intervention measures during a preliminary book reading session (<10 model steps; <25 encourage steps; <10 respond steps). To control for possible history effects from the dyad becoming better acquainted with each other as communication partners over the course of the study, a prior familiar relationship between the EA and the child was critical. See Table 2.1 for participant overview.
<table>
<thead>
<tr>
<th>Child, Age</th>
<th>G</th>
<th>Disability</th>
<th>Communication</th>
<th>TACL-3</th>
<th>EA, Age</th>
<th>Education</th>
<th>Classroom Experience</th>
<th>Previous AAC Exp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ava, 4;7</td>
<td>F</td>
<td>ID</td>
<td>Limited speech (&lt;10 words), vocalizations, gestures, choice boards, access to SGDs for some activities</td>
<td>61</td>
<td>2;8</td>
<td>&lt;1</td>
<td>0</td>
<td>1-2 trainings</td>
</tr>
<tr>
<td>Ben, 4;4</td>
<td>M</td>
<td>ASD</td>
<td>Limited speech (&lt;5 words), vocalizations, gestures, choice boards, visual schedule, limited access to SGDs during therapy sessions</td>
<td>57</td>
<td>2;6</td>
<td>&lt;1</td>
<td>0</td>
<td>1-2 trainings</td>
</tr>
<tr>
<td>Cassie, 3;9</td>
<td>F</td>
<td>ASD</td>
<td>Limited speech (&lt;5 words), vocalizations, gestures, choice boards, visual schedule, access to SGDs for some activities</td>
<td>59</td>
<td>2;3</td>
<td>&lt;1</td>
<td>0</td>
<td>None</td>
</tr>
</tbody>
</table>

*Note.* Pseudonyms used. ASD = Autism spectrum disorder; I-ASCC = Index of Augmented Speech Comprehensibility in Children (Dowden, 1997); ID = Intellectual Disability; EA = Educational Assistant, TACL-3 = Test of Auditory Comprehension of Language, 3rd Edition (Carrow-Woolfolk, 1999) SS = standard score, AE = age equivalent, %=percentile rank
Ava and Amanda

Ava, a 4-year, 7-month-old girl, was identified with an intellectual disability and attended her inclusive preschool classroom four full days per week. Teacher report noted strengths in socialization and challenges in communication, motor skills, adaptive behavior, and vision. Ava was described as frequently walking into the classroom with a smile and giving kind greetings to favorite school staff by hugging or waving. She was reported as speaking less than ten intelligible words and using some vocalizations. Ava used communication techniques for making choices such as AAC picture cards and occasional access to various speech generating devices (SGDs). Ava scored a standard score of 61, considered very poor, on the Test of Auditory Comprehension of Language, 3rd ed. (TACL-3) (Carrow-Woolfolk, 1999) indicating below average language comprehension skills. Ava did not use speech to respond to any of the probes of The Index of Augmented Speech Comprehensibility in Children (I-ASCC) (Dowden, 1997). While Ava was able to walk, her balance was unstable and she occasionally fell. Additionally, she was observed struggling with her hands for fine motor tasks such as manipulating a crayon during coloring. She depended on adults for assistance with most self-care routines, such as with meals. During the course of the study, Ava began wearing glasses to correct minor myopia. Ava's hearing was within the normal range as reported in her Individualized Education Plan (IEP).

Amanda

Amanda, a 21-year-old female, participated in the study as Ava's EA. At the start of the study, she had worked as Ava’s one-to-one assistant for approximately one year. In addition to working at the preschool, Amanda was majoring in special education at a local university. Amanda had three years of experience working in early childhood and had participated in one to two AAC focused trainings previous to the study. Amanda stopped working at the center during
the study, which prevented her from starting post-intervention sessions immediately following intervention, but was able to return after one month for two post-intervention sessions with Ava.

**Ben and Brooke**

Ben, a 4-year, 4-month-old boy, was identified with autism and attended a classroom designed for children with autism spectrum disorders four full days per week. He also attended an inclusive preschool classroom for one full day per week. Ben attended an after-school program at the inclusive preschool classroom five afternoons a week. The teacher report noted concerns in Ben’s communication, social interaction with teachers and peers, and fine motor skills. Teacher report stated that Ben spoke less than five intelligible words and was reported to struggle with using gestures and vocalizations. Ben used a line drawing symbol-based schedule board with assistance from adults for daily communication. Ben’s SGD access was limited to speech therapy sessions. Administration of the TACL-3 (Carrow-Woolfolk, 1999) indicated a standard score of 57, rated as very poor, which signaled below average receptive language skills. Ben was unable to use speech to respond to the probes of the I-ASCC (Dowden, 1997). Ben demonstrated significant delays in fine motor skills including during play and academic tasks. Ben had vision and hearing within normal limits as reported in his IEP.

**Brooke**

Brooke, a 24-year-old female, served as Ben's EA during the study and had worked with Ben for over three months. Brooke worked with Ben regularly throughout each day in learning and therapeutic centers inside the classroom. She had completed some college, but was not attending classes at the time of the study. Brooke had four years of experience working in an early childhood setting and had participated in one to two AAC focused trainings previous to the study. During the course of the study Brooke indicated that she would be accepting a job at a new center, which prohibited collecting data during more than two post-intervention sessions.
Cassie and Colette

Cassie, a 3-year, 9-month-old girl, was identified with autism and attended a classroom designed for children with autism spectrum disorders four full days per week. Teacher report noted that Cassie had intense, but limited interests. She enjoyed sensory-based experiences like exploring toys that produced sound, light, and movement feedback. Yet, Cassie struggled to maintain attention during a range of play and academic centers. Teacher report stated that Cassie spoke less than five intelligible words and that she used vocalizations mainly for protest and would use limited gestures such as moving an adult's hand to do a certain task. Cassie's SGD access was limited to various therapy activities throughout the day and she was reported to inconsistently communicate her wants and needs. Cassie's TACL-3 (Carrow-Woolfolk, 1999) score was 59, considered very poor, which suggested below average language comprehension skills. Cassie was unable to use speech to respond to any of the probes of the I-ASCC (Dowden, 1997). Many fine and gross motor tasks were often difficult for Cassie. She required assistance with feeding, completing school tasks such as using a marker, and walking due to difficulty with balance. Cassie had vision and hearing within normal limits as reported in her IEP.

Colette

Colette, a 24-year-old female, was Cassie's EA during the study and had one year of experience as Cassie's one-to-one assistant. While she worked in the classroom program, she was attending a university and majoring in early childhood education. Colette had one year of experience working in an early childhood education setting and had no previous experience attending an AAC focused training.

Coach

The lead researcher for the study served as the coach during the EA training session. The coach provided tutoring during intervention sessions using the bug-in-the-ear system. At the time
of the study, he was a PhD candidate in special education, had a master's degree in assistive technology, and an undergraduate degree in special education, elementary education, and history.

**Materials**

Intervention materials included a combination of commercially available items, the books, iPads, AAC software, case, keyguard, computers, and Bluetooth headset used during the shared storybook reading sessions. Other materials were specifically designed for the child, EA, and coach. Specially designed materials included AAC vocabulary displays, child and EA reminder cards, the iBook used during training.

**Child materials**

**Books**

The general recommendation is that any picture book can be used for dialogic reading, but for the book to have clear illustrations, relatively little text, and an engaging story (Zevenbergen & Whitehurst, 2003). Based on an adaptation of those general directives, the current study's book selection criteria for the shared storybook reading sessions included: (a) simple subject matter, (b) pictures, (c) topics for young children, (d) the presence of core vocabulary, and (e) short length (books with a total word count of approximately 50 to 100 words). Each shared storybook reading session included two books donated by Houghton Mifflin Harcourt from the Red Level Rigby Books collection (Red level connotes Rigby levels three to five and Directed Reading Assessment levels two to three). The researcher and a second rater each reviewed the book set and found each book to include all desired storybook criteria. See Appendix G for an example book cover.

**AAC vocabulary displays**

The AAC displays, containing the words the child could use for communication, were constructed on an Apple iPad using the AAC software application Proloquo2Go (Sennott &
Niemeijer, 2008). Proloquo2Go was selected because of the application's ability to be customized for this study's purposes. The dual-screen AAC display step up included two iPads that were each housed in a Big Grips case, which is a large foam enclosure designed to keep the device in a secure, consistent and accessible position for the child and EA. See Appendix H for a photograph of the iPad in the Big Grips case and stand. Note that each iPad was running the same AAC vocabulary display, but each iPad was running independently of the other iPad. This differed from other dual-display methods utilizing screen sharing technology where there is one computer running the software, but two screens available to show the same content on each (Quach & Beukelman, 2010). The default vocabulary displays consisted of 32 words in an 8 x 4 inch landscape grid, including approximately 22 core words adapted from the words most frequently used by toddlers (Banajee, DiCarlo and Stricklin, 2003). Additionally, approximately ten book-relevant vocabulary words were included on the display. See Appendix I for examples of vocabulary displays.

These ten book-relevant vocabulary words were chosen and added to the AAC display by the researcher and research assistants based on a three-step process. First, the book was read and all words from the book were added to a table that included headings for major parts of speech. Second, based on review, words deemed important for talking about the book were added to a ten-item table. Third, words and symbols for those words were added as items on the AAC vocabulary displays. Every word on the AAC displays included the written text of the word (all 32 words for Ben and Cassie and 16 words for Ava) and the majority of words also included a symbol (typically 28/32 words per display for Ben and Cassie and 15/16 for Ava). Words such as "what", "who", "you", and "do" did not include symbols, but just the written word. The symbols included one or more of the following: images taken from the corresponding book, and when necessary, line drawings from two popular AAC symbol sets, the SymbolStix symbol set and the Minspeak symbol set. See Appendix J for examples of symbols from each set. The symbols for
the book-specific vocabulary words consisted mostly of photographs taken from the books. For example, the book-specific vocabulary words for a book about chimpanzees included photographs of the chimpanzees, trees, and a vine, all taken from the book. The children’s SLPs were consulted to determine if the default vocabulary display required adaptations with regard to symbols, vocabulary, and item and display size (Beukelman & Mirenda, 2013). Only one child, Ava, needed her iPad to be customized from the default setup. Her iPad was customized to suit her motor and visual needs and included a 4 x 4 inch portrait-oriented grid vocabulary display (including eight core and eight book-specific words per display) and a Lasered Pics plastic keyguard (a piece of plastic cut to the size of the iPad screen with holes cut out for each item on the AAC display and affixed with suction cups to the iPad). Because Ava required these accommodations, the number of words dropped from 32 to 16 on her display. See Appendix K for a depiction of Ava's setup and the keyguard.

For each reading session, the child and EA each received iPads configured identically. The Apple iPad accessibility feature Guided Access (a way to lock the iPad's buttons and mask desired areas of the screen) was enabled to keep the participants inside the AAC software and out of the complicated options menus. See Appendix L to see the setup screen for Guided Access on the iPad. When the child and EA received the iPad at the start of the session, the screen showed a launcher page that included the two book vocabulary folders that linked to each book-specific vocabulary. See Appendix M for a depiction of this screen.

**Child reminder card**

A three by five reminder index card listing the intervention components of ModelER for Read and Talk (Read and Talk) was provided to the child during the intervention. The child reminder card was used to initially introduce the child to the shared storybook reading session and was available to the EA to remind the child of the activity in case of distraction. In order to
provide a greater sense of ownership of the reminder card, the EA and child were provided with markers and colored the reminder card before first use. See Appendix N.

**EA materials**

**Training materials**

Training materials consisted of a mix of digital- and paper-based tools. The EA used an iPad with the iBooks and Proloquo2Go applications, and a sample paper storybook from the Red Level Rigby book set. The researcher created a custom iBook using Apple's iBook Author software. The iBook included various interactive features, such as animations, embedded custom slide shows, quizzing, and simulations. See Appendix O for examples from the iBook.

Chapter one of the interactive iBook targeted introducing background knowledge (step one) and discussing ModelER for Read and Talk (step two). EAs navigated through the interactive iBook content that included: (a) a set of descriptions and operational definitions of ModelER for Read and Talk that included an interactive timeline; (b) a set of multi-media slideshows focused on description of an analogy that helped with memorizing the strategy; (c) a set of interactive pages focused on the theoretical rational and evidence base for ModelER for Read and Talk; and (d) a self-scoring interactive review that used the quiz features of the interactive iBook.

Chapter two of the iBook included video based models of ModelER for Read and Talk being performed (step three). The EA and researcher watched, discussed, and reviewed annotated videos from the preliminary study in this section of the training. Each video contained a specific target focus area such as modeling, responding, or promoting back and forth conversation.

Chapter three of the iBook aimed to provide memorization practice for ModelER for Read and Talk (step four) and support for performing the intervention (step five). Interactive memorization elements included reviewing the interactive timeline, reviewing the analogy, writing reminder notes on a virtual whiteboard, and studying flashcards generated through the
highlighting feature of the iBook. Support for performing the intervention concentrated on (a) live simulation of the intervention using Proloquo2Go and the paper based storybook; (b) a video based simulation focused on labeling elements of instruction; and (c) a video based simulation focused on talking about situations taken from the preliminary study.

**EA reminder card**

A three by five reminder index card listing the intervention components of ModelER for Read and Talk (Model, Encourage, Respond, Read, and Talk) was provided to the EA during the intervention. The EA reminder card stated each part of the intervention and was either attached via tape discretely to the top of the storybooks or placed on the table, dependent on EA preference. The EA reminder card was designed as an optional tool for prompting use of the intervention components. See Appendix N.

**Coaching materials**

To facilitate coaching and tutoring during the shared storybook reading intervention, a novel bug-in-the-ear tutoring system was designed. This system allowed for immediate feedback to the EA who could hear the coach through a Bluetooth headset (Scheeler, McAfee, Ruhl, & Lee, 2006). The primary components of the bug-in-the-ear tutoring system included: (a) the session device—a laptop running Skype pointed at the child and EA during the reading session; (b) the tutor device—a laptop running Skype that the coach could use to watch the reading session; (c) a Bluetooth headset connected to the session device; (d) a wired USB headset connected to the tutor device; and (e) a secure Wi-Fi network connecting the two computers on a local area network (allowing for very low audio and video latency) with internet access (allowing Skype to authorize the computer to computer connection). See Appendix P for a diagram of the bug-in-the-ear setup.
Measurement

Pre-assessments

The Test of Auditory Comprehension of Language, 3rd ed. (TACL-3) (Carrow-Woolfolk, 1999) was used to measure receptive language and was administered according to the standard procedures which included speaking the prompt, "show me", plus the target word (e.g., cat). The children were expected to point to one of four pictures on the page and their answers were recorded. The TACL-3 is considered a reliable and valid instrument. The internal consistency, time sampling, and scorer differences reliability scores were .97, considered very high (Carrow-Woolfolk, 1999). The history of the TACL-3's use as a research tool in studies involving speech and language (e.g., Kent-Walsh et al., 2010), and the strong construct validity and criterion-related validity in relation to other well validated related receptive vocabulary assessments make the TACL-3 appropriate for use in this study (Carrow-Woolfolk, 1999).

The Index of Augmented Speech Comprehensibility in Children (I-ASCC) (Dowden, 1997) was administered with standard procedures to measure speech intelligibility. Standard procedures for this criterion-referenced assessment consisted of displaying a series of single images and asking the child, "What's that?" and recording their spoken response. The I-ASCC word pool was derived from a set of words typically acquired before age three as validated by the MacArthur Bates Communicative Development Inventories (Fenson et al., 1993). The I-ASCC was administered using the iPad and the open source photo set developed by for the I-ASCC (Sennott, 2012). All three of the children were unable to produce a spoken response to any of the images in the I-ASCC.

Shared storybook reading measures

The researcher provided the EA and child with two different storybooks per 10-min scored session and an iPad loaded with each books' corresponding AAC vocabulary displays. At the start of the baseline phase shared storybook reading sessions, the researcher directed the EAs
to read as they normally would with the child. No instructive feedback was provided. If instructive feedback was requested by the EA, the researcher redirected the EAs to the initial directive, to read as they normally would.

**Number of communication turns**

The student target behavior measurements consisted of the: (a) per minute frequency of communication turns and (b) modality of the communication turn. Definitions of a communication turn from both Carter (2003) and Light et al (1992) were adapted for the current study. Similar to Light et al (1992) child communications turns included engagement in a communicative act through one or more of the following communication modalities: (a) AAC device use, (b) speech, (c) sign language use, (d) gesture, and (e) vocalization. The communication turns had to include some evidence of intentionality (Carter, 2003). An example of a communication turn was the child touching the AAC symbol on the iPad for dog or gesturing to a picture of the dog in the book. Accidental AAC activations such as pressing the iPad with some part of the body, like an elbow, were not counted as an iPad AAC turn. Matching the approach from Light et al (1992) and Light, Collier, and Parnes (1985a) the boundary of communication turns was either: (a) the EA initiating a turn or (b) a five-second period without student engagement in communication. Similar approaches have been used in related studies (Kent-Walsh et al, 2010; Rosa-Lugo & Kent-Walsh, 2008).

**Modality of communication turns**

Each child communication turn was analyzed for the communication modality the child used, which included: (a) AAC device use: an iPad AAC turn, (b) speech: a speech turn, (c) sign language use: a sign turn, (d) gesture: a gesture turn, and (e) vocalization: a vocalization turn. Turns could include use of multiple modalities. For instance, the child could point to a
chimpanzee in the book and tap the AAC symbol for chimpanzee on the iPad. This single communication turn included two modalities, gesture and AAC.

**EA treatment fidelity**

EA target behavior measurements included: (a) model step (AAC models), (b) encourage steps (time delay), and (c) respond steps (AAC recasts). The model step consisted of the EA AAC modeling by performing the activation of at least one AAC symbol on the iPad and speaking out loud before, during, or after the model. Model step turns by the EA were separated by either the child initiating a turn or five seconds without EA activation of an AAC symbol on the iPad. Pointing to an item on the AAC system and activation of navigational items were not counted as AAC models. Measurement of the encourage step (time delay) component was adapted from Halle, Baer, and Spradlin (1981) and consisted of: (a) the EA not vocalizing, using AAC, or performing another activity such as turning pages in the book until the child took a turn or for at least five seconds, and (b) the EA looking in the direct ion of the child. The respond step (AAC recasting) component was adapted from Nelson and colleagues (1996) and consisted of the EA: (a) providing a multi-symbol AAC model, (b) repeating some part of what the child had just previously communicated, and (c) providing some sort of correction of grammar or expansion of the child’s utterance. See Table 2.2 for examples.
Table 2-2: Examples of each ModelER Step

<table>
<thead>
<tr>
<th>ModelER step</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) The EA reads, &quot;Little Chimp wakes up.&quot; As she is speaking, on the iPad, she presses the AAC symbols LITTLE, CHIMP, WAKES, UP. (2) The EA comments by pressing the AAC symbols LITTLE, CHIMP, IS, FUNNY and speaks those words.</td>
<td></td>
</tr>
<tr>
<td>Encourage step</td>
<td>After reading and AAC modeling, the EA looks at the child and waits for them to take a turn. The child promptly takes a turn by pressing an AAC symbol on the iPad.</td>
</tr>
<tr>
<td>Respond step</td>
<td>The child presses the AAC symbols CHIMP, FUNNY. The EA provides an AAC recast by pressing the AAC symbols YES LITTLE CHIMP IS FUNNY and speaks those words.</td>
</tr>
</tbody>
</table>

Post-intervention assessment

Following study completion, the researcher conducted an anonymous treatment acceptability survey that asked EAs about their experiences with the intervention in accordance with the goal of evaluating acceptability and viability of a programmed intervention as outlined in Schwartz & Baer (1991). See Appendix Q for complete survey.

Design

The study utilized a single-subject multiple-baseline, multiple-probe design across participants (Gast, 2010; Kazdin, 2011). IES-recommended guidelines for meeting evidence standards in single-case design were employed: (a) the researcher systematically manipulated the independent variable; (b) each outcome variable was measured over time by more than one observer and inter-observer agreement was collected for least 30% of the data points in each phase of the study per participant and met minimum thresholds; (c) three demonstrations of an intervention effect occurred at three different points in time; and (d) five or more data points were collected in each phase of the study per participant (Kratochwill et al., 2010).

Before instruction occurred for any participants, baseline phase data was collected, six points for Ava, four for Ben, and four for Cassie. The criterion for participants to transition from baseline to intervention included the child's frequency of communication turns being both low
and stable in baseline without a positive trend. A low and stable baseline was defined as a mean of less than <2 communication turns per minute for the child and a standard deviation of less than 1. Trend was assessed through visual analysis of the baseline data.

For all three participants, the time between baseline ending, the training occurring, and intervention resuming was short. Training occurred immediately following baseline and intervention reading sessions resumed the next school day for Ava and Cassie and after two school days for Ben due to scheduling demands. Ava entered the intervention phase first, while Ben and Cassie remained in baseline. After Ava achieved criterion of three intervention sessions with a 50% mean difference in communication turns from baseline, Ben entered the intervention phase, while Cassie remained in baseline. After Ben reached criterion, Cassie entered the intervention phase. The intervention phase consisted of five sessions for Ava, five for Ben, and six for Cassie. After each participant competed at least five intervention sessions, they entered post-intervention with Ava and Ben each having 2 sessions and Cassie having 4 sessions. To demonstrate maintenance of intervention effects over time, two post-intervention sessions were conducted at least 21 days after the last session in the intervention condition for both Ava and Cassie. Ben’s EA was unable to complete maintenance sessions because of a change in employment.

Scoring

Video data capture

The configuration of the video cameras for data capture included two cameras each capturing different angles. The first camera was focused head-on in order to view the overall session activities and the EA’s face for coding time delay. The second camera was positioned behind the participants and focused in on the book, the iPad-based AAC displays, and the participants. Using the video editing software Final Cut Pro, the video files generated during each shared storybook reading session were synched using the automatic synching feature and hand-
tuned by aligning the audio tracks when necessary. The synched video files were then combined using a picture-in-picture effect with the secondary shot displayed in the corner of the primary shot’s video, allowing the scorers to see both angles at the same time when coding EA and child measures.

**Video analysis**

The multi-camera video set-up that included two iPod Touches as high-definition video cameras mounted to tri-pods captured all shared storybook-reading sessions. The cameras were positioned so that the faces of the EA and student and use of the AAC communication systems were visible. Scorers watched the session videos and coded for target behaviors for EAs and students with the video analysis software StudioCode. The scorers were graduate students in special education who had taken coursework in research methods, completed IRB training, and completed a four hour study-specific training that involved watching sample videos and practicing coding using coding guides in order to develop competency to acceptable reliability levels (above 80%) in scoring study measures.

**Coding and transcription**

The two scorers coded the EA and student target behaviors through a custom-coding window developed with the software StudioCode. See Appendix R for the custom-coding window. As the scorers watched the videos, they selected the appropriate codes for EA and student behavior. Scorers transcribed child turns during shared storybook reading sessions using an adaptation of the Higginbotham and Engelke (2013) AAC transcription methodology and StudioCode's transcription features. The procedure included first coding child communication turns and then adding the transcribed text to those code items using a system for annotation. See Appendix S for annotation guide.
**Inter-observer agreement**

Inter-observer agreement was conducted for at least 30% of the sessions in each study phase per participant for each of the following measures including total child communication turns, iPad AAC turns, speech turns, gesture turns, and vocalization turns. A point-by-point agreement ratio was calculated according to methodology described in Kazdin (2011), using the following formula:

\[
\text{Point-by-point agreement} = \frac{A}{A + D} \times 100
\]

where A equaled number of agreements and D equaled number of disagreements on an opportunity-by-opportunity basis. EA and child measures’ point-by-point agreement scores were within acceptable limits for reliability (Kazdin, 2011).

For total number of child turns the mean was 88% (range=81%-92%). For iPad AAC turns the mean was 94% (range=91%-100%). For turns using speech the mean was 98% (range=93%-100%). For turns using vocalizations the mean was 86% (range=58%-100%). For turns using gestures the mean was 92% (range=77%-100%).

**Transcript agreement**

Two scorers transcribed a minimum of 30% of sessions in each phase of the study for student transcript agreement using an adaptation of the methodology outlined in Kent-Walsh, Binger, & Hasham (2010). iPad AAC turns, gesture turns, and intelligible speech were included in the transcription. Transcript agreement calculations were performed for student transcripts by dividing total number of agreements by the number of agreements plus disagreements, the same formula used for inter-observer agreement. The transcript agreement mean equaled 88% (range=80%-92%), demonstrating reliable transcription.
**EA treatment fidelity**

Using the same methodology as inter-observer agreement, EA treatment fidelity was conducted for at least 30% of the sessions in each study phase per participant. For total AAC models by EAs, the mean was 89% (range=86%-91%). For the model step the mean was 81% (range=78%-85%). For the respond step the mean was 89% (range=85%-93%). For the encourage step the mean was 77% (range=72%-80%). The latter was expected to be lower due to the historical difficulty in scoring this measure (Halle et al., 1981).

**Intervention procedures**

**Pre-assessment**

Prior to collecting baseline data, the children and EAs participated in pre-assessments including the TACL-3 and the I-ASCC at the school. In addition, the researcher conducted the pre-assessment shared storybook reading session with the child and EA, providing them with the storybooks and two iPads loaded with the AAC vocabulary displays. They were given the prompt to read as they normally would.

**Baseline**

The baseline phase incorporated 10-min scored shared storybook reading sessions for each participant in a staggered format across time, including six sessions for Ava, seven for Ben, and eight for Cassie. Baseline sessions (as well as intervention and post-intervention sessions) were scheduled as frequently as possible; up to the four days a week the children attended school. The procedures were identical to the pre-assessment storybook reading sessions. Following baseline, the intervention package was introduced for one participant, while all other participants remained in baseline.
**EA training**

Fidelity of treatment was established during the training session provided to the EA and the bug-in-the-ear tutoring provided during shared storybook reading intervention sessions. The six components of training included the following steps: (1) develop background knowledge; (2) discuss ModelER for Read and Talk; (3) model ModelER for Read and Talk; (4) memorize ModelER for Read and Talk; (5) support ModelER for Read and Talk; and (6) engage in independent performance of ModelER for Read and Talk (Archer & Hughes, 2010). In order to proceed with subsequent shared storybook reading sessions EAs needed to be trained by successfully completing a researcher led training session.

EAs engaged in a combination of live instruction and eLearning-based instruction with the custom iBook on the Apple iPad. The iPad was placed in between the researcher and the EA. The EA primarily engaged with the iBook by swiping the screen to turn pages and tapping, swiping, and dragging on the screen to interact with the content. EA participants completed the researcher led training session at school in one to two sessions lasting 80- to 111-min. The researcher led training sessions were delivered over one session with the EAs Amanda and Colette and over two sessions on consecutive days for Brooke, due to school scheduling demands. The duration of training varied from a low of 80-min for Colette, to 96-min for Amanda, to a high of 111-min for Brooke. Additionally, the time between baseline ending, the training occurring, and intervention resuming was short. Training occurred immediately following baseline and intervention reading sessions resumed the next school day for Ava and Cassie and after two school days for Ben due to scheduling demands.

**Procedural fidelity for training**

Two scorers reviewed 100% percent of the training sessions and relevant shared storybook reading sessions (for step six targeting independent practice) for correct
implementation of the six steps in the training measures. The researcher successfully completed all of the six steps with all three EAs, with 100% agreement by the two raters.

**Instruction**

Following the training session, 10-min scored reading sessions resumed marking the start of the intervention phase of shared storybook reading sessions. The EA had been trained in using ModelER for Read and Talk and during the shared storybook reading with the child, received tutoring in using the intervention by the coach through the bug-in-the-ear system.

During instruction, the researcher served as a tutor through a bug-in-the-ear set-up (Scheeler, McAfee, Ruhl, & Lee, 2006). This tutoring approach provided beneficial immediate feedback (Scheeler, Ruhl, McAfee, 2004) in a discrete manner designed to be less distracting than during the preliminary study that included the tutor at the table with the EA and child. As sessions proceeded in a nearby room, the researcher monitored live video feed on a laptop via Skype. Speaking into a headset connected to the laptop, he was able to speak to the EA, who listened through a Bluetooth headset, allowing for immediate feedback. Feedback was a mix of positive, specific, and corrective statements (Scheeler, Ruhl, & McAfee, 2004) designed to guide the EA toward successful implementation of ModelER + Read and Talk. For example, the researcher would say, “Nice model" or "good encourage, now respond". See Table 2.3 for additional examples. Additionally, at the start of the intervention phase, the EA was coached to use the reminder chart to help self-regulate intervention performance.

<table>
<thead>
<tr>
<th>Type</th>
<th>Purpose</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal Prompt</td>
<td>Cue desired behavior.</td>
<td>“Remember to AAC model reading on this next page”</td>
</tr>
<tr>
<td>Specific feedback, positive</td>
<td>Reinforce correct behavior</td>
<td>“Nice waiting”</td>
</tr>
<tr>
<td>Specific feedback, corrective</td>
<td>Bring awareness of errors to be corrected</td>
<td>“You expanded, but forgot to model. Add an AAC model during your respond step.”</td>
</tr>
</tbody>
</table>
The bug-in-the-ear tutoring system functioned adequately for providing immediate feedback to EAs during nearly all of the intervention sessions. One exception came during the scheduled second intervention session for Ava and Amanda. During this session, the Bluetooth headset the EA used in the bug-in-the-ear system repeatedly malfunctioned, prohibiting a session from occurring. After analysis of the malfunction, the researcher determined that the Bluetooth headset had a feature that enabled it to automatically power off when not continuously in use. The solution for subsequent intervention sessions was to stream music through the Bluetooth headset prior to the start of the session, allowing the connection to be maintained.

In order for subsequent participants to enter the intervention phase, the current child in the intervention phase needed to meet intervention criterion levels for communication turn increases—at least a 33% mean difference from baseline to intervention over three storybook reading sessions. Intervention participants transitioned to post-intervention following five sessions for Ava and Ben and six sessions for Cassie with a minimum of a 50% mean difference from baseline.

**Post-intervention**

During the post-intervention phase, conditions equaled intervention conditions with two exceptions: the researcher no longer provided bug-in-the-ear tutoring and the reminder charts were removed. Post-intervention sessions were conducted immediately following the intervention phase and in order to evaluate maintenance, post-intervention sessions were also conducted at least 21 days after the last session in the intervention condition. Amanda was an exception because her EA began student teaching and was unable to start post-intervention sessions immediately following intervention. For Amanda, two post-intervention sessions were conducted one month after instruction and due to afternoon scheduling of the sessions, the sessions were only five-min in duration. Ben was also an exception, because his EA transferred positions, only allowing two post-intervention sessions immediately following instruction.
Data analysis

Analysis of child communication performance and EA treatment fidelity was conducted using single subject research analysis procedures. Visual analysis of level and trend was the primary technique employed in the analysis of results (Kazdin, 2011). Additionally, percentage of non-overlapping data (PND) (Scruggs, Mastropieri, & Casto, 1987), calculated as the ratio of the number of intervention data points above the highest baseline point (Parker, Vannest, & Davis, 2011), were calculated. PND was chosen because it describes how many data points were higher than baseline levels. PND's primary limitation is easily observable, where there is the potential for 100% non-overlapping data to be just above baseline levels where the clinical change is not meaningful. Descriptive statistics in the form of means and standard deviations were also calculated.
Chapter 3

Results

Results of visual and descriptive analysis indicate that the three child participants increased communication turns during shared storybook reading sessions. Following participation in the ModelER for Read and Talk intervention, educational assistants (EAs) demonstrated increases in the number of augmentative and alternative communication (AAC) models, time delays, and AAC recasts they performed during shared storybook reading.

Child communication

Each child’s communication is reported for communication turns (see Figure 3.1) and modality (see Figure 3.2) performance. Descriptive statistics (means and standard deviations) and percentage of non-overlapping data (PND) are also reported (see Table 3.1).
Figure 3-1: Per minute frequency score of child communication turns taken during 10-minute reading sessions.

Note: Post-intervention sessions for Ava were five-minutes in duration.
Figure 3-2: Per minute frequency score of the modality of child communication turns taken during 10-minute reading sessions.

*Note:* Post-intervention sessions for Ava were five-minutes in duration.
Table 3-1: Means, Standard Deviation, and PND for child communication turn per minute frequency scores for 10-minute shared storybook reading sessions

<table>
<thead>
<tr>
<th>Child</th>
<th>Communication turn type</th>
<th>Mean (Standard Deviation)</th>
<th>Baseline</th>
<th>Intervention</th>
<th>Post-Intervention</th>
<th>PND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ava</td>
<td>Total Turns</td>
<td></td>
<td>1.25(.49)</td>
<td>3.32(.81)</td>
<td>3.4(.57)</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>iPad AAC</td>
<td></td>
<td>.7(.57)</td>
<td>2.98(1.01)</td>
<td>3.3(.71)</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Speech</td>
<td></td>
<td>&lt;.1(.08)</td>
<td>.12(.27)</td>
<td>0(0)</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Vocalizations</td>
<td></td>
<td>&lt;.1(.09)</td>
<td>.26(.23)</td>
<td>0(0)</td>
<td>60%</td>
</tr>
<tr>
<td></td>
<td>Gestures</td>
<td></td>
<td>.37(.25)</td>
<td>&lt;.1(.18)</td>
<td>&lt;.1(.14)</td>
<td>0%</td>
</tr>
<tr>
<td>Ben</td>
<td>Total Turns</td>
<td></td>
<td>&lt;.1(.13)</td>
<td>1.78(.49)</td>
<td>1.9(.28)</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>iPad AAC</td>
<td></td>
<td>0(0)</td>
<td>1.78(.49)</td>
<td>1.8(.14)</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Speech</td>
<td></td>
<td>&lt;.1(.04)</td>
<td>0(0)</td>
<td>0(0)</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Vocalizations</td>
<td></td>
<td>&lt;.1(.05)</td>
<td>0(0)</td>
<td>.1(.14)</td>
<td>14%</td>
</tr>
<tr>
<td></td>
<td>Gestures</td>
<td></td>
<td>&lt;.1(.05)</td>
<td>0(0)</td>
<td>0(0)</td>
<td>0%</td>
</tr>
<tr>
<td>Cassie</td>
<td>Total Turns</td>
<td></td>
<td>&lt;.1(.12)</td>
<td>2.77(1.2)</td>
<td>2.33(.73)</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>iPad AAC</td>
<td></td>
<td>0(0)</td>
<td>2.75(1.2)</td>
<td>2.3(.71)</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Speech</td>
<td></td>
<td>0(0)</td>
<td>&lt;.1(.05)</td>
<td>0(0)</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>Vocalizations</td>
<td></td>
<td>&lt;.1(.07)</td>
<td>&lt;.1(.04)</td>
<td>0(0)</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Gestures</td>
<td></td>
<td>&lt;.1(.12)</td>
<td>0(0)</td>
<td>0(0)</td>
<td>0%</td>
</tr>
</tbody>
</table>

Note. AAC= Augmentative and Alternative Communication, PND = Percentage of non-overlapping data, post-intervention sessions for Ava were five-minute sessions versus the usual 10-minute sessions.

Ava

During the baseline phase, Ava had mean ($M$) = 1.25 turns per min (standard deviation ($SD$) = .49). The frequency of Ava's communication turns initially demonstrated a downward trend followed by stabilization over the last three baseline sessions (see Figure 3.1). Ava demonstrated the use of AAC, speech, vocalization, and gesture communication modalities at baseline with AAC and gesture turns being the most frequently used modalities. Ava was the only child who took iPad AAC turns during this phase, with $M = .7$ ($SD = .57$) turns per min. Additionally, Ava took a number of gesture turns at baseline, with $M = .37$ ($SD = .25$) turns per min. Few speech or vocalization turns were performed during the baseline phase, with $M < .1$ for each modality.

Based on EA concerns regarding Ava's physical access to the AAC vocabulary display on the iPad, Ava's AAC vocabulary display was modified after the third baseline session. The AAC
vocabulary display changed from a 4 X 8 landscape-oriented display to a 4 X 4 portrait-oriented display and a plastic keyguard was added. These changes were made in consultation with Ava's speech language therapist and were designed to better accommodate her visual and motor needs. Ava's total communication turn performance was consistent before and after the change, indicating no impact of the changed equipment on communication turn performance. Ava's highest total frequency of communication turns per min across the three baseline sessions, prior to the change in AAC vocabulary display was 1.8 turns. This was comparable to her highest total in the three sessions following the change, 1.5 turns. Also indicating no impact of the changed equipment on communication turn performance, Ava experienced an additional level change from baseline levels in iPad AAC turns immediately following the start of the intervention phase.

*Ava intervention*

Upon entering the intervention phase, Ava's total number of communication turns showed an immediate level change and demonstrated an upward trend over the course of the intervention phase. Starting at the third intervention session, Ava began wearing glasses, but no apparent changes in level or trend for total communication turns or modality were detected following this change. The level increases from baseline over the first two intervention sessions, previous to the introduction of the glasses, were maintained in subsequent intervention sessions. iPad AAC turns were the most frequently used modality during intervention, with $M = 2.98$ ($SD = 1.01$) turns per min. Gesture turns decreased during the intervention phase, with $M < .1$ ($SD = .18$) turns per min. Her level of vocalizations $M = .26$ ($SD = .23$) and speech $M = .12$ ($SD = .27$) turns per min increased in intervention. Overall, Ava's mean number of communication turns during the intervention phase increased to $M = 3.32$ turns ($SD = .81$) turns per min with 100% PND.
**Ava post-intervention**

For Ava, the post-intervention phase was conducted a month after intervention, due to EA scheduling, and consisted of two five-min sessions, due to child fatigue during the late afternoon sessions. A downward trend was present over these two data points. iPad AAC turns were the most frequently used modality during the post-intervention phase $M = 3.3$ ($SD = .71$) turns per min. In post-intervention, Ava decreased in gesture turns $M < .1$ ($SD = .14$), speech turns $M = 0$ ($SD = 0$), and vocalization turns $M = 0$ ($SD = 0$). Overall, compared to baseline, Ava's number of communication turns during post-intervention increased with $M = 3.4$ turns ($SD = .57$) with 100% PND.

**Ben**

Ben averaged less than one communication turn per session, with $M = < .1$ ($SD = .13$) turns per min in baseline and was stable with no data trend. Ben took turns using gestures, with $M < .1$ ($SD = .05$) turns per min and with vocalizations with $M < .1$ ($SD = .05$) turns per min. A single speech turn was taken during baseline sessions and no iPad AAC turns with the iPad were demonstrated during baseline.

**Ben intervention**

After entering the intervention phase, Ben demonstrated an immediate level change in frequency of communication turns with an upward trend to the data over the phase. iPad AAC turns were the only modality represented during intervention $M = 1.78$ ($SD = .49$) turns per min. Ben did not demonstrate any speech, vocalization, or gesture turns during intervention. Overall, Ben's mean frequency of communication turns during intervention increased to $M = 1.78$ ($SD = .49$) turns per min with 100% PND.

**Ben post-intervention**

Increased frequency of communication turns was maintained during post-intervention with a positive trend present over the two data points. In post-intervention, iPad AAC turns were
the most frequently used modality, with $M = 1.8$ ($SD = .14$) turns per min. Ben decreased in gesture turns, with $M = 0$ ($SD = 0$) per min and with speech turns ($M = 0$, $SD = 0$) per min, but increased in vocalization turns, with $M = .1$ ($SD = .14$) per min. Overall, Ben's frequency of communication turns during post-intervention increased to $M = 1.9$ ($SD = .28$) turns per min with 100% PND.

**Cassie**

During baseline, Cassie averaged less than one communication turn per session, with $M = <.1$ ($SD = .12$) turns per min and had a stable level and trend. Cassie demonstrated no AAC or speech turns. She used gesture turns, with $M <.1$ ($SD = .12$) per min and vocalization turns, with $M <.1$ ($SD = .17$) per min during baseline.

**Cassie intervention**

Immediately upon beginning the intervention phase, Cassie made an immediate level change in frequency of communication turns, reaching 5.1 turns per min in the first session. A downward trend in the data followed and continued across intervention, but the level change from baseline was maintained over the course of intervention. iPad AAC turns were Cassie's predominant modality used during intervention, with $M = 2.75$ ($SD = 1.2$) turns per min. During intervention, the change in Cassie's vocalization turns was negligible, with $M <.1$ ($SD = .04$) per min and she did not use speech or gesture turns. Overall, Cassie increased her frequency of communication turns during intervention to $M = 2.77$ ($SD = 1.2$) turns per min with 100% PND.

**Cassie post-intervention**

Cassie's increased communication turn level was maintained during post-intervention with downward trend to the data. Compared to baseline, Cassie increased iPad AAC turns to $M = 2.33$ ($SD = .71$) per min and speech turns to $M <.1$ ($SD = .05$) per min, but did not take any vocalization or gesture turns. Overall, Cassie's frequency of communication turns in post-intervention increased to $M = 2.33$ ($SD = .73$) turns per min with 100% PND.
Summary

At baseline, Ben and Cassie both had means of less than .1 communication turns per min and Ava had a mean of 1.25 turns per min. The modality of the communication turns taken by the children included iPad AAC turns (Ava), speech turns (Ava, Ben), gesture turns (all), and vocalization turns (all). Sign language was not used as a modality by any of the participants across any of the phases of the study.

During intervention, all three children increased the frequency of communication turns taken during the shared storybook reading sessions demonstrating 100% PND (see Figure 3.1). In the intervention phase, iPad AAC turns were the predominant modality of the children's communication turns across all participants, with a range of 87% to 100% of all turns being iPad AAC turns (Ava = 87% iPad AAC turns, Ben = 100% iPad AAC turns, Cassie = 99% iPad AAC turns) (see Table 3.1). During post-intervention, all three children maintained the communication turn frequency increases made during intervention and had 100% PND from baseline. iPad AAC turns continued to be the main modality used during post intervention (Ava = 97% iPad AAC turns, Ben = 95% iPad AAC turns, Cassie = 99% iPad AAC turns).

EA performance

The total number of AAC models, model steps, respond steps (see Figure 3.3) and encourage steps (see Figure 3.4) are reported for EA performance. Descriptive statistics (M and SD) and PND are also reported (see Table 3.2).

Model and Respond Steps

At baseline, Amanda was the only EA demonstrating the model step (AAC models), but did not perform any instances of the respond step. Brooke performed one AAC model during the entire baseline phase. Colette was not yet performing AAC models during baseline.

Across all three EA participants, there were level changes in the per min frequency of AAC models, which was comprised of both the model steps and respond steps (See Figure 3.3).
Additionally, Amanda and Brooke's total number of AAC models both had an upward trend over the course of intervention with each of their highest total number of AAC models occurring during the last and second to last intervention sessions respectively. In contrast, Colette’s data trended downward across both intervention and post-intervention phases and her highest total number of AAC models occurred during the first intervention session. Overall, the three EAs demonstrated increases in the total number of AAC models implemented per min during intervention (Amanda $M = 4.42$, $SD = .5$; Brooke $M = 3.02$, $SD = .61$; Colette $M = 3.82$, $SD = .94$) with 100% PND. These gains were maintained during post-intervention (Amanda $M = 4.8$, $SD = 1.13$; Brooke $M = 3.5$, $SD = .57$; Colette $M = 2.78$, $SD = .24$) with 100% PND.

**AAC model type**

The increases in total AAC models were comprised of increases across both the model step and the respond step. EAs differed in the predominant intervention step they performed during the study (see Figure 3.3). While at baseline, the EAs did not perform any instances of the respond step. During intervention, Amanda (Respond step $M = 2.48$, $SD = .55$; Model step $M = 1.94$, $SD = .15$) and Colette (Respond step $M = 2.33$, $SD = .72$; Model step $M = 1.58$, $SD = .25$) both performed more respond steps than model steps. During intervention, Brooke's data demonstrated the opposite, more model steps than respond steps (Model step $M = 2.06$, $SD = .17$; Respond step $M = 1.16$, $SD = .27$). All three EAs demonstrated the same patterns during post-intervention as during intervention (see Table 3.2).

**Time delays**

All three EAs made increases in the frequency of encourage steps they performed per min (see Figure 3.4). At baseline, both Brooke ($M = .13$, $SD = .13$) and Colette ($M < .1$, $SD = .08$) demonstrated low and stable levels of encourage steps per min and each averaged less than two instances over the phase. By comparison, Amanda performed higher levels of encourage steps at baseline, with $M = .63$ instances ($SD = .31$). Amanda had 1.7 instances of encourage steps per
min in her first baseline session and then showed a downward trend over the course of baseline to a low of .2 encourage steps per min in both sessions four and the final session six.

Upon entering intervention, all three EA participants experienced an immediate increase in the per min frequency of encourage steps they performed (Amanda $M = 2.64$, $SD = .51$; Brooke $M = 1.82$, $SD = .28$; Colette $M = 1.73$, $SD = .69$). No overall trend was demonstrated in the encourage step data across participants during the intervention phase. Similar increases were maintained during post-intervention for all three EAs (See Table 3.2). Across post-intervention Colette and Brooke had positive trends, while Amanda had a negative trend. All EAs demonstrated considerable amounts of variability in performance, yet still maintained overall increases from baseline to intervention with 100% PND. These increases were continued from baseline to post-intervention, with 100% PND for all participants (see Figure 3.4).

Table 3-2: EA intervention components Means, Standard Deviation, and PND

<table>
<thead>
<tr>
<th>EA (Child)</th>
<th>Component</th>
<th>Mean (Standard Deviation)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Amanda (Ava)</td>
<td>Total AAC models</td>
<td>.63 (.31)</td>
<td>4.42 (.5)</td>
<td>4.8 (.13)</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Model step</td>
<td>.63 (.31)</td>
<td>1.94 (.15)</td>
<td>2.2 (.57)</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Respond step</td>
<td>0 (0)</td>
<td>2.48 (.55)</td>
<td>2.6 (.57)</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Encourage step</td>
<td>.63 (.56)</td>
<td>2.64 (.51)</td>
<td>2.5 (.99)</td>
<td>100%</td>
</tr>
<tr>
<td>Brooke (Ben)</td>
<td>Total AAC models</td>
<td>&lt;.1 (.04)</td>
<td>3.02 (.61)</td>
<td>3.5 (.57)</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Model step</td>
<td>&lt;.1 (.04)</td>
<td>2.06 (.17)</td>
<td>2.1 (.28)</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Respond step</td>
<td>0 (0)</td>
<td>1.16 (.27)</td>
<td>1.4 (.28)</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Encourage step</td>
<td>.13 (.13)</td>
<td>1.82 (.28)</td>
<td>1.15 (.78)</td>
<td>100%</td>
</tr>
<tr>
<td>Colette (Cassie)</td>
<td>Total AAC models</td>
<td>0 (0)</td>
<td>3.82 (.94)</td>
<td>2.78 (.24)</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Model step</td>
<td>0 (0)</td>
<td>1.58 (.25)</td>
<td>1 (.36)</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Respond step</td>
<td>0 (0)</td>
<td>2.23 (.65)</td>
<td>1.78 (.53)</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Encourage step</td>
<td>&lt;.1 (.08)</td>
<td>1.73 (.69)</td>
<td>2 (.77)</td>
<td>100%</td>
</tr>
</tbody>
</table>

Note. AAC= Augmentative and Alternative Communication, PND = Percentage of non-overlapping data, post-intervention sessions for Ava were five-minute sessions versus the usual 10-minute sessions.
Figure 3-3: The per minute frequency of AAC models performed by EAs during 10-minute shared storybook reading sessions, categorized by type of AAC model.

Note: Post-intervention sessions for Amanda and Ava were five-minutes in duration.
Figure 3-4: The per minute frequency of encourage steps (time delays) performed by EAs during 10-minute shared storybook reading sessions.

Note: Post-intervention sessions for Amanda and Ava were five-minutes in duration.
Training system

Treatment acceptability survey

EA treatment acceptability survey results suggested overall positive evaluations of the ModelER for Read and Talk intervention. See Appendix Q for full survey results. All three EAs perceived the intervention as helping them become better prepared to assist the child they worked with learn to use AAC and would recommend the intervention to others. Critiques of the intervention program included wanting a more customized AAC system for the child, wanting to see the intervention in a more general environment, and wanting to see the program expanded beyond shared storybook reading.
Chapter 4

Discussion

Results of this study indicate that children and educational assistant’s (EA) performance improved as a result of participation in the Model, Encourage, Respond for Read and Talk (ModelER) intervention. Following intervention, all three children immediately demonstrated increases in the number of communicative turns taken during shared storybook reading sessions with 100% percentage of non-overlapping data (PND). The growth in the number of child communication turns consisted of increases in iPad augmentative and alternative communication (AAC) turns, while other communication modalities were marginally impacted. Also, EA instructional performance was characterized by increases in the total number of AAC models (Model and respond steps combined) and encourage steps provided, both with 100% PND. These gains followed participation in less than 120-min of ModelER training, plus bug-in-the-ear tutoring during shared storybook reading sessions. Child and EA performance increases were also maintained during the post-intervention phase of the study.

This study targeted pragmatic gains in the form of increased communication turns by children with complex communication needs (CCN), and who had autism or intellectual disabilities. Study results support the hypothesis that training EAs in ModelER provides the instructional supports needed to assist children with CCN in making pragmatic communication gains (increased communication turns). Importantly, the results of this study support and extend findings reported in a meta-analysis of AAC modeling (Sennott, Light, & McNaughton, 2012) and the pilot ModelER for Read and Talk study (Sennott & Mason, 2012).

This dissertation posed two interrelated questions regarding children’s communicative performance and educational assistant’s instructional performance. The first question addressed
the impact of ModelER on child communication performance, specifically the frequency of communication turns. During preschool, children are expected to rapidly develop pragmatic, syntactical, and morphological skills, as well as a burgeoning vocabulary (Adamson, 1995; Tomaselllo, 2001). Yet, in the present study, selected children took few communication turns prior to intervention, which was problematic for both learning and practicing language.

In the current study, the ModelER intervention stimulated increased communication turns, which promoted increased opportunities for interaction. Fey (1986) described the importance of increased opportunity for interacting, which he asserted creates increased opportunities for practicing and targeting specific language goals. Related, Kent-Walsh et al. (2010) and Rosa-Lugo and Kent-Walsh (2008) also reported that children with CCN increased their turn-taking performance when provided more opportunities to interact during shared storybook reading. In summary, these results indicate a promising method for positively impacting child communication performance, thereby promoting language acquisition by children with CCN who use AAC.

The first research question also examined the modality of the children's communication turns. Child language development is impacted by the complex interaction of the child's abilities in all domains including motor, vision, hearing, cognition, and language (Siegel & Cress, 2002). Children in the present study were using less than 10 spoken words in their entire repertoire, which indicated the need to develop an intervention that would promote communication and ultimately influence language development (Paul, 2007). During baseline performance, all children demonstrated limited use of multiple modalities including vocalizations and gestures, and two of three children did not use any functional AAC device. When the ModelER intervention was introduced, as indicated above, children's communicative turn taking performance was positively affected. The primary communication modality for all children shifted to the AAC device, that is, an Apple iPad (86%-100% of each participant's turns). This
change was expected because EA training created a focus on using the AAC device during the shared storybook reading session with the child. Overall, for all study participants, gains in total number of communication turns and the modality shift to an AAC device exemplify what one EA stated in her treatment acceptability survey, "the device became the student's voice" (see Appendix Q).

The second research question examined the impact of ModelER on EA instructional performance. Results suggested large increases across target areas of EA instructional performance, including increased model, encourage, and respond steps (AAC models, time delays, and AAC recasts). The positive impact on EA instructional performance matched similar studies targeting EA behavior during shared storybook reading (Kent-Walsh et al., 2010; Rosa-Lugo & Kent-Walsh, 2008), which adds to the AAC communication partner training evidence base. These results are consistent with research and theory in child language acquisition related to the importance of providing input and interaction with speech (Hart & Risley, 1995), sign language (Bavelier, Newport & Supalla, 2003; Newport & Supalla, 2000), and AAC (Sennott, Light, & McNaughton, 2012). Children with CCN are at risk of experiencing problems with language development (Beukelman & Mirenda, 2013) and the EAs who work with these children play a very important role in scaffolding language development. In summary, these results support the importance of training communication partners to use a systematic process whereby all facets of an intervention are systematically and accurately introduced to promote communicative performance among children with CCN who are learning to develop language.

These findings are especially important because EAs are key special education team members who often spend the majority of their day supporting children with CCN in early childhood educational experiences (Giangreco, Edelman, Broer, & Doyle, 2001). Unfortunately, these team members have been reported as not being the recipients of training that promotes language-related skills (Giangreco, Edelman, Broer, & Doyle, 2001; Giangreco, Suter, Doyle,
Prior to their involvement in the present study, one EA reported not having previously been trained in AAC and two EAs reported one to two previous training experiences in AAC. In the present study, EAs received 1-2 hours of training in the use of the ModelER intervention. As a result of their training, EAs were able to follow training protocols with better than 85% fidelity. Importantly, the ModelER intervention was well received by EAs, who reported that training helped them “feel better prepared to work with children learning to use AAC.” Additionally, EAs reported that they would recommend similar training to other EAs and a range of other special education team members. Overall, results indicate that the ModelER intervention is an easy to learn communication system that results in important communication outcomes that are easily recognized by EAs who typically may be responsible for promoting important communication outcomes.

Additionally, the present study resulted in an interesting finding related to the use of a bi-directional framework of input and interaction between the child and EA (see Figure 4.1).

Figure 4-1: Bi-directional input and interaction framework
Previously, various frameworks of AAC input have often been linear, emphasizing the role of providing speech and AAC input to children with CCN (see Figure 4-2).

![Diagram showing unidirectional and bidirectional models of input and interaction](image)

Figure 4-2: Unidirectional input and interaction framework based on Porter (2007) and Smith and Grove (2003)

The current study, in addition to emphasizing the role of speech and AAC input by the communication partner also highlighted (a) the interactive role of child communication turns and (b) the interactive role of EA responses. A bi-directional model better depicts the complex interactions that occur when both the child and EA are taking turns, influencing each other (see Figure 4-1).

**Language development**

For children with CCN we know typical interactions often lack AAC models and infrequently provide opportunities for expressive communication (Blockberger & Sutton, 2003; Smith & Grove, 2003). These deficits potentially interfere with the language acquisition process for children with CCN who require AAC. The current study addressed both of these concerns through training EAs to perform three intervention components: (a) providing AAC models while reading the book and making comments or asking questions, (b) supplying wait time in order to
give the child communication opportunities (i.e., time delay), and (c) supporting the child's communication attempts with responsive feedback in the form of AAC recasts. While the results of the current study were positive and demonstrated large pragmatic language gains in the form of increased communication turns (i.e., increased interaction), the study lacked a measure of vocabulary acquisition, and did not include a focus on teaching specific target vocabulary. Additional research is needed to determine what the children ascertained from the intervention regarding vocabulary knowledge, a crucial component of language development. Research is also needed to investigate ModelER impact across the various domains of language development. Priorities should include additional pragmatic language goals and skills across phonology, syntax, and morphology domains.

**Limitations and future research**

While the results of the current study are promising, there are significant limitations present across the areas of participants, accessibility, AAC vocabulary displays, and training.

**Participants**

The small number of participants and strict inclusion criteria for participation severely limits the ability to generalize to the larger population of children with autism or intellectual disabilities, even if they present similar communication profiles. Considering the diverse population of children with autism, intellectual disabilities, and CCN in general (Beukelman & Mirenda, 2013) it is especially important to replicate the findings of this study across additional participants. A limitation in the study was that Cassie demonstrated a higher data point in her initial intervention session adding to an overall downward trend in her data, similar to one of the participants in Kent-Walsh, Binger, and Hasham (2010). Anecdotally, it appeared that she experienced initial excitement to be focusing on the iPad and then became more accustomed to
using it during the subsequent reading sessions. Future research with more participants could help clarify these types of patterns in the data.

Additionally, EA participant attrition limited the ability to fully conduct maintenance data for two of the participants in the study, which limited the ability to fully estimate the possible impact of the ModelER intervention over longer periods of time. This is important because an AAC intervention such as ModelER is expected to produce additional gains over time (Beukelman & Mirenda, 2013; Romski & Sevcik, 1996).

**Accessibility**

All three children in the current study experienced a degree of difficulty physically accessing the displays, with one participant, Ava, eventually requiring a simplified display and a keyguard. The other two participants Ben and Cassie were able to use the default displays, but still had difficulty isolating their fingers to access the displays. Future research should directly investigate the role of access to the AAC device. Future research should include children with varying motor skills and those who use alternate access options such as touch screens with keyguards (as in the present study), computer mouse alternatives (joysticks, trackpads etc.), switch scanning systems, head tracking systems, eye tracking systems, gestural interfaces, and brain computer interfaces.

**AAC vocabulary displays**

In the treatment acceptability survey, EAs discussed the need for further customizations of the AAC system to better meet the individual needs of the child, a point well supported in the AAC field (Light & Drager, 2007). While in the current study the displays were customized in consultation with the children's speech and language pathologist, future research could investigate more fully customized AAC systems. This future research could incorporate children just
beginning to use various AAC vocabulary approaches such as visual scene displays (Light & Drager, 2007) and Pragmatically Organized Dynamic Displays (PODD) (Porter, 2007).

**Training**

In response to the need for additional practice opportunities and non-intrusive immediate feedback (Scheeler, McAfee, Ruhl, & Lee, 2006), the ModelER intervention was enhanced to include additional simulated practice opportunities and more discrete tutoring through the bug-in-the-ear system. A limitation of the current study was that the bug-in-the-ear system for cuing EAs to follow training protocols did not include a treatment fidelity measurement. Future research could include transcripts of the bug-in-the-ear feedback coded for type of feedback. Overall, future research could include enhancing the simulation components of the ModelER intervention further enabling EAs to efficiently gain additional levels of practice prior to introducing communication training to children with CCN.

Additionally, it is important to note that the current study investigated a multi-component intervention, which limits our understanding of the contributions of the iPad, the bug-in-the-ear system, and each ModelER component when accounting for increases in child communication turns. Future systematic research is needed to provide a more precise understanding of the role of each component of the intervention.
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Appendix A

Meta-analysis of AAC Modeling

For many individuals, speech serves as their primary language tool, and the development of sophisticated speech and language skills occurs in a relatively fluid sequence throughout childhood and early adolescence (Adamson, 1995; Bates, 1976; Brown, 1973; Hart & Risley, 1995; Miller & Chapman, 1986; Pinker, 2000; Tomasello, 2003). The development of communication skills begins in the first years of life (Adamson, 1995). Light (1997) describes this as a “magical” period when children move through using pre-intentional and pre-symbolic communications (e.g., reaching + pointing to objects) to the use of complex syntax and the wide vocabulary available with spoken language (Paul, 1997). During this time, children are surrounded by rich models of speech (Gallway & Richards, 1994; Snow & Ferguson, 1978), and adults engage children in numerous interactions, which serve to support speech and language development (Hart & Risley, 1995; Tomasello, 2003).

For individuals with complex communication needs (CCN) - individuals with disabilities such as autism, cerebral palsy, and other developmental disabilities which can hinder the use of speech, the use of augmentative and alternative communication (AAC) can provide a way to communicate with others (Beukelman & Mirenda, 2005). AAC refers to the use of strategies, other than speech, to communicate - for example, the use of pictures, signs, gestures, and speech generating devices (SGDs). AAC can be divided into two main categories: unaided and aided (Beukelman & Mirenda, 2005). The term unaided AAC refers to using only the body to communicate, for example, the use of sign language or gestures. Aided AAC refers to communicating with items separate from the body such as pointing to pictures in a paper communication book or the use of a computer based system.
The early experiences of individuals who require AAC are different from those of speaking individuals in at least two important ways. First, unlike speaking children, individuals with CCN rarely observe models of the use of their expressive communication system (in this case, AAC) by others (Romski & Sevcik, 1996; Smith & Grove, 2003; Blockberger & Sutton, 2003). Second, they are less likely than speaking children to participate in interactions in which they have opportunities to make use of their expressive communication system (i.e., AAC) with others (Blockberger & Sutton, 2003; Calculator, 1997; Calculator & Dollaghan, 1982; Light, 2003; Siegel & Cress, 2002). The sparseness of these early language development experiences has serious implications for the development of important early communication and language skills.

**Language Development of Speaking Children**

Observations of typical child language development can provide a theoretical framework for examining the development of communication by children with complex communication needs (Fey, 1986; Gerber & Kraat, 2003). Despite the serious controversies surrounding competing theories of language acquisition, virtually all major theories (e.g. nativist, emergentist, social interactionist) agree that communicative input and interaction is of importance in the language acquisition process (Gerkin, 2008; Hirsh-Pasek & Golinkoff, 1996). With respect to language input, both quantity and quality are important (Hart & Risley, 1995; Gallway & Richards, 1994; Tomasello, 2003; Snow & Ferguson, 1978).

**Quantity of Input.** There is a strong positive correlation between the number of words a normally developing child hears, and the child’s language development. Hart and Risley (1995) reported that a typically developing child is surrounded by speech and will hear approximately 26 million words between birth and age four. This means approximately 1,250 words per hour for a child from an average family, with regards to talkativeness and 2,150 words per hour for a child from an above average talkative family. The number of words that a child hears before age three strongly predicted both the child’s rate of receptive and expressive vocabulary at age three.
Additionally, both the number of words the child hears and their expressive vocabulary at age three strongly predicts their expressive vocabulary at age nine (Hart & Risley, 1995).

**Quality of Input.** In addition to knowing that most speaking children hear a large quantity of words it is important to note that the words are embedded within a social context, creating a quality of input experience. Tomasello (2003) describes how adults create social interactions where the adult engages the child in a shared activity, directs the attention of the child, and introduces new vocabulary and language structures.

The language directed at children is often unique, called “motherese” or child-directed speech, and is characterized by various elements meant to engage and maintain the attention of the child by using higher pitch, slower tempo, more exaggerated intonation, more simplistic utterances, and more repetitions with a higher focus on the child and his or her immediate interests (Gallaway & Richards, 1994; Snow & Ferguson, 1978). During these shared social interactions the adult appears to be attempting to develop a “common ground” with the child (Tomasello, 2003), language input that is appropriate to the child’s current level of understanding, but which gradually introduces new vocabulary and new pragmatic, semantic, and grammar skills as well. These interactions are occurring in naturalistic social contexts where the adult has harnessed the child’s attention and language modeling is occurring.

**Language Development for Children Who Require AAC**

The language that most children with CCN receive as input, speech, is not the same medium they use to actively construct and manipulate in order to express themselves, AAC. (See figure 1) Smith and Grove (2003) characterized this situation as one of an “ansynchrony of input to output”. Along with the asynchrony of input, children with CCN often experience input less rich in both number and types of words used (Light, 1997; Light, Collier, & Parnes, 1985a; Light, Collier, & Parnes, 1985b). Therefore these children generally receive less experience with models of pragmatic, semantic, syntactic, and morphological forms.
Figure 1. Diagram of speech only input during interaction versus AAC modeling and speech input during interaction for an individual with CCN who requires AAC
Modeling Based Intervention Approaches

In order to address this need, a number of similar interventions have been proposed as a way to provide rich language input in the form of AAC input to individuals who will use aided AAC expressively. Aided language stimulation (ALgS) (Goosens’, 1989; Goosens’, Crain, and Elder, 1992), augmented language input (Romski & Sevcik, 1996), natural aided language (Cafiero, 2001), aided language modeling (Drager, Postal, Carrolus, Castellano, Gagliano, & Glynn, 2006), and aided AAC modeling (Binger & Light, 2007) are all approaches that refer to the interactive usage and modeling of an augmentative communication system by a communication partner for a learner.

For the purposes of this meta-analysis, interventions described as AAC modeling based all contain two key features: (1) engaging in the context of a naturalistic communication interaction, and (2) modeling of aided AAC. These components are derived from considering the quantity and the quality of the interactions provided for children and how they contribute to driving their language acquisition (Tomasello, 2003). A naturalistic communication interaction is a communication interaction defined as a “dynamic process between at least two people which is highly interactive, bi-directional and multi-modal” (Kraat, 1985, p. 21) and occurs naturally in the context of the learners day. Examples of naturally occurring activities are a child participating in a play routine or reading a book with an adult at home or school. The second component involves the modeling of aided AAC. As they are speaking, the communication partner (e.g. a parent, teacher) points to, or in some way draws the learner’s attention to vocabulary items in the child’s AAC system (or a copy of the child’s system). The goal is that the adult “models” the expressive use of the AAC system of the child. Modeling has been found to be a vital factor in a range of language learning interventions (Hart & Risley, 1975; Koegel & Koegel, 2006; Warren & Kaiser, 1986; Warren & Yoder, 1997).
Meta-analysis Rationale and Goals

In the field of AAC, it is imperative to engage in systematic reviews, and meta-analysis in particular (Schlosser, 2005) on topics such as AAC modeling because of the large group who make up the population of individuals with CCN, estimated at 1.3% of the population of the United States, nearly four million Americans, spanning across a range of ages and disabilities (Beukelman & Mirenda, 2005). Reviewing research of AAC interventions that hold promise or are believed to be effective, such as AAC modeling, is critical to understanding which practices are optimal for aiding in skill development for individuals with CCN, and under which conditions such interventions should be effective. In particular, a review of AAC modeling interventions is of interest because of the strong theoretical foundation for the importance of language input, which is presented in the general linguistic literature (Gallway & Richards, 1994; Gerkin, 2008; Hart & Risley, 1995; Hirsh-Pasek & Golinkoff, 1996; Snow & Ferguson, 1978) and in the AAC related literature (Goosens’, Crain, and Elder, 1992; Light, 1997; Romski & Sevcik, 1996; Smith & Grove, 2003).

This meta-analysis addresses the question, “What is the effect of AAC modeling based interventions on the communication performance of individuals with AAC needs?” In order to thoroughly appraise the relevance of the evidence reviewed, it is important to investigate a number of specific sub-questions such as:

1. Who has AAC modeling based interventions been investigated with?
2. What specific skills have been taught?
3. What is the nature of the instruction provided?
4. What is the general impact on communication performance?
5. What future research would help in better understanding the effect of AAC modeling based interventions?

Determining the nature of the practice of AAC modeling based interventions and the
impact it has on communication performance is important for both practitioners looking to adopt effective practices (Horner et al., 2005) and for researchers carefully deciding which practices to systematically investigate. Looking at options for future research based on the current state of the research base provides next step questions to be explored. Taken together, the goal of investigating these questions is to help stakeholders make informed decisions regarding the evidence of the impact of AAC modeling based interventions.

**Methods**

A two-part inclusion criteria was used. First, included articles were published in an English language peer reviewed journal from 1989 to the present. The date was chosen based on the publishing of the initial case study investigating the use of ALgS by Goosens’ (1989). Second, articles needed to report a primary intervention variable that included 1) engaging in the context of a naturalistic communication interaction, 2) harnessing of the language learner’s attention, and 3) modeling of aided AAC.

An electronic search was performed using the PsychInfo and the Educational Resources Information Center (ERIC) databases. The search query used was [(aided language stimulation) or (system for augmenting language) or (augmented input)) or (aided language modeling) or (modeling)] AND [(augmentative and alternative communication) or (AAC) or (augmentative)]. The search yielded a total of 274 citations to be evaluated. Additional search methods used included a manual search of the journal *Augmentative and Alternative Communication*, an ancestral search of initially identified articles, and contact to those authors by emailing about additional articles. Ultimately, 17 studies were identified to be evaluated for meeting a certainly of evidence criteria for the meta-analysis. (See Table 1) A number of articles were published from the longitudinal research study described in Romski and Sevcik (1996) and two articles (Romski, Sevcik, Robinson, & Bakemen, 1994; Wilkinson, Romski, & Sevcik, 1994) are included as representative works because they report different parts of the data set.
Methodological elements of each study were then analyzed based on quality indicators for single subject research (Horner et al., 2005) or group design research (Gersten et al., 2005) and were translated into one of four major certainty of evidence categories (Simeonsson & Bailey, 1991; Smith, 1981) similar to those used in Millar, Light, & Schlosser, 2006). The certainty of evidence categories were: a) conclusive evidence (b) preponderant evidence; (c) suggestive evidence; or (d) inconclusive evidence. A best evidence analysis approach was used (Slavin, 1986; Millar, Light, & Schlosser), with only conclusive levels of evidence being included in the meta-analysis. The following steps were used to determine the certainty of evidence, adapted from Millar et al., (2006), Horner et al., (2005), and Gersten et al., (2005):

1. The two group design studies, Romski et al., (2010) and Kent-Walsh, Binger, and Malani (2010), each lacked a control group, a critical element of the 38 quality indicators listed in Gersten et al. (2005), which immediately determined they would be categorized as inconclusive.

2. For the remaining 14 studies (Romski et al., 1994) and Wilkinson et al., (1994) were evaluated as a single entry), each study was analyzed according to the 20 quality indicators for single subject design research listed in Horner et al. (2005) across the following general categories: (a) description of participants and setting, (b) dependent variable, (c) independent variable, (d) baseline, (e) experimental control/ internal validity, (f) external validity, and (g) social validity. A yes or no response was recorded for each of the 20 indicators and was designed to inform the consideration of whether the study met the overall certainty of evidence criteria.

3. The analysis of the quality indicators was used to inform the determination of whether a study should be categorized overall as (a) conclusive evidence (i.e. the design demonstrates experimental control, the independent and dependent variables were reliable, and the participants were adequately described providing convincing evidence that the treatment was
responsible for the results); (b) preponderant evidence (i.e. minor flaws were present in the
design, reliability of the independent or dependent variable, or description of the participants
proving slightly less convincing evidence that the treatment was responsible for the results);
(c) suggestive evidence (i.e. multiple minor flaws were present in the design, reliability of the
independent or dependent variable, or description of the participants; it is plausible the
treatment was responsible for the results; or (d) inconclusive evidence (i.e. major flaws were
present in the design and the study did not establish experimental control, providing
unconfirmed evidence that the the treatment was responsible for the results).

Meta-analytic Procedures

The goal of using meta-analytic procedures for this study was to provide a clearer, more
scientific picture of the evidence. Three primary statistics were chosen specifically for the data set
with a goal of using multiple measures to aide in triangulating accurate results, similar to the
approach Miller (2011) took. The three statistics included two non-overlap techniques (Parker,
Vannest, & Davis, 2011), percentage of non-overlapping data (PND) and percentage of non-
overlapping data exceeding the median (PEM), and one effect size score, Busk and Serlin’s
(1993) standard mean difference (SMD), approach one. A total of 22% of the studies and 26% of
the demonstrations were reviewed by a second rater for accuracy with 100% agreement on the
participant level data set drawn from the article, PND, PEM, mean difference, and SMD (with the
exception of an isolated copy and paste error only for PEM that was corrected). PND has been
both a useful and controversial statistic in the meta-analysis of single subject research. It was used
in this study because it is clear, understandable both in strengths and weaknesses, and relevant for
this data set where the baselines tend to be relatively stable. PEM, a slightly less conservative
statistic, has been used as a complimentary measure to PND. By having a view of the non-overlap
of the highest baseline point, PND, and the median baseline point, PEM, it provides a slightly
clearer estimate of how much of the baseline condition overlapped intervention, mainly showing
if multiple points are overlapping. One important weakness of PND occurs when there is a high amount or even 100% non-overlapping data, but the intervention condition scores are only a small amount above the baseline scores. In this case a high score does not necessarily translate into a meaningful gain from baseline to intervention. Busk and Serlin’s SMD (1992) was used in order to provide an estimate of a meaningful, standardized gain of participants, accounting for within subject variability present in the baseline condition. SMD approach one is calculated by subtracting the baseline mean from the treatment mean and dividing by the standard deviation of the baseline.

\[
SMD = \frac{M_t - M_b}{SD_{b - \text{pooled across Ss}}}
\]

Problems occur when the baseline variance is zero and the solution used for this study, was to pool the standard deviation of the baselines across all participants in an individual study as outlined in Gierut and Morrisette (2011). Two corrections were also necessary. First, the Binger et al., (2010) study had a zero baseline across all data points so the SMD was calculated from the Pooled SD from Binger et al., (2008) due to a the similarity of design, which was a direct replication. Second, the Binger et al., (2011) study had an artificially low pooled SD, due to all but one condition having zero variance in the baseline. Therefore, the SD of that one condition with variance was used to calculate the SMD. For comparison purposes, the mean difference (MD) was also reported alongside the SMD. It was calculated by subtracting the mean of the baseline condition from the mean of the intervention condition.

**Results**

The 17 identified studies incorporated a variety of research designs. (See Table 1) Yet, only nine studies, all single subject multiple baseline designs, had designs strong enough to be included in the meta-analytic portion of this study. Three of the 17 were case studies, which lack experimental control. Despite the limitations in methodology as compared to single subject
designs (Horner et al., 2005), these case studies provided in-depth descriptions of materials and intervention techniques for populations highly at risk for language acquisition difficulties. Examples of this are (a) Goossens’ (1989), which described a six year old girl with multiple disabilities in both the clinic and home setting, (b) Cafiero (2001), which described a 13 year old boy with autism in the school setting, and (c) Bruno and Trembath, (2006) which described a case study about nine learners attending an AAC focused summer camp. Two of the 17 studies used group designs that lacked a control group, (a) Romski et al., (2010), which compared 63 participants in three randomized intervention conditions, and (b) Kent-Wash, Binger, and Malani (2010), a within-subjects group design with 10 participants that incorporated a pre-test, intervention, post-test format. Two studies used a longitudinal design and a range of analysis techniques over two years (Romski et al., 1994; Wilkinson et al., 1994), providing the most comprehensive study over time, yet lacked designs that provided adequate experimental control to be included in the meta-analysis. Ten of the studies were single subject designs. Nine used multiple baseline designs, the studies included in the meta-analysis, and one an ABAB design with adults in the context of a music activity (Beck et al., 2009), which did not meet criteria due to a number of issues, specifically around description of the IV and DV. Single subject design studies provide some of the most relevant evidence because of the experimental benefits of these designs with diverse populations such as AAC users (Schlosser, 2003).
<table>
<thead>
<tr>
<th>Studies and design</th>
<th>Subjects, gender, disability, (age)</th>
<th>Context, setting</th>
<th>Target skills</th>
<th>Independent variable</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goosens’ (1989) Case Study</td>
<td>1 f w/ CP (6)</td>
<td>Play, daily activities w/ clinicians, parent in clinic + home</td>
<td>Turn taking, vocabulary, combining words</td>
<td>Aided language stimulation including ongoing AAC modeling with paper board + switch scan</td>
<td>Increase: turn taking, rec. + exp. vocabulary, combining words, speech</td>
</tr>
<tr>
<td>Romski, Sevcik, Robinson &amp; Bakeman (1994) Longitudinal</td>
<td>13 m w/ DD (6;2 -20;5) (M=12;4)</td>
<td>Mealtime, recreation w/ teachers, family in school + home</td>
<td>Turn taking, vocabulary, combining words</td>
<td>System for Augmenting Language including AAC modeling with 9.4% of utterances with SGD</td>
<td>Increase: turn taking, rec. + exp. vocabulary, combining words</td>
</tr>
<tr>
<td>Wilkinson, Romski, &amp; Sevcik (1994) Longitudinal</td>
<td>13 m w/ DD, autism (6;2 -20;5) (M=12;4)</td>
<td>Mealtime, recreation w/ teachers + family in school + home</td>
<td>Vocabulary, combining words</td>
<td>System for Augmenting Language including AAC modeling with 9.4% of utterances with SGD</td>
<td>Increase: combining words, novel syntax structures</td>
</tr>
<tr>
<td>Cafiero (2001) Case Study</td>
<td>1 m w/ autism (13)</td>
<td>Mealtime, academics w/ school staff in school</td>
<td>Turn taking, vocabulary, academics</td>
<td>Natural aided language intervention including ongoing AAC modeling with paper board</td>
<td>Increase: turn taking, exp. vocabulary, academics</td>
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<td>Harris &amp; Reichele (2004) Multiple baseline, (probe)</td>
<td>2 m, 1 f w/DD (3;10 -5;4)</td>
<td>Play w/ teacher in school</td>
<td>Rec. + exp. vocabulary</td>
<td>Aided language stimulation with 4 AAC models of each target vocabulary word with paper board</td>
<td>Increase: rec. + exp. vocabulary</td>
</tr>
<tr>
<td>Drager, Postal, Carrolus, Castellano, Gagliano, &amp; Glynn (2006) Multiple baseline, (probe)</td>
<td>1 f, 1 m w/ autism (4;0 - 4;5)</td>
<td>Play w/ clinician in daycare</td>
<td>Rec. + exp. vocabulary</td>
<td>Aided language modeling with 4 AAC models of each target vocabulary word with paper board</td>
<td>Increase: rec. + exp. vocabulary</td>
</tr>
<tr>
<td>Studies and design</td>
<td>Subjects, gender, disability, (age)</td>
<td>Context, setting</td>
<td>Target skills</td>
<td>Independent variable</td>
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<tr>
<td>Bruno &amp; Trembath (2006) Case Study</td>
<td>9 w/ CP, Apraxia, Schizencephaly, and DS (4;8 -14;5)</td>
<td>Arts and crafts, storytelling in summer camp</td>
<td>Combining words, morphology</td>
<td>Aided language stimulation with multi-symbol AAC modeling SGD condition: 5 to 8 models and Paper board condition: 3 to 5 models</td>
<td>Increase: n=5 combining words, n=7 subject-verb order, n=4 +ing</td>
</tr>
<tr>
<td>Binger &amp; Light (2007) Multiple baseline, (probe)</td>
<td>3 m, 2 f w/ Prader-Willi, DiGeorge Syn., DS, Dev. delay (3 - 5)</td>
<td>Play w/ clinician in school = 3 + home = 2,</td>
<td>Combining words</td>
<td>Aided AAC modeling intervention with a minimum of 30 multi-symbol AAC models with SGD</td>
<td>Increase: n=4 combining words</td>
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<tr>
<td>Binger, Kent-Walsh, Berens, Del Campo, &amp; Rivera (2008) Multiple baseline, (probe)</td>
<td>1m, 2f w/ motor speech impairments (2;11, 3;4, 4;1)</td>
<td>Story book reading w/ parent in home</td>
<td>Combining words</td>
<td>Read, Ask, Answer intervention with AAC modeling of up to 3 multi-symbol models per page spread with SGD</td>
<td>Increase: combining words</td>
</tr>
<tr>
<td>Rosa-Lugo &amp; Kent-Walsh, (2008) Multiple baseline, (probe)</td>
<td>1 m, 1 f w/ cystic hygroma, DD, (6;8, 6;9)</td>
<td>Story book reading w/ parent in home</td>
<td>Turn taking, vocabulary</td>
<td>Read, Ask, Answer intervention with AAC modeling of up to 3 models per page spread with SGD</td>
<td>Increase: turns taken, exp. vocabulary</td>
</tr>
<tr>
<td>Beck, Stoner, &amp; Dennis (2009) Single subject ABAB</td>
<td>3 f, 3 m w/ DD (25-35)</td>
<td>Music activity w/ clinicians in adult day program</td>
<td>Turn taking</td>
<td>Aided language stimulation intervention with ongoing AAC modeling with SGD + paper board</td>
<td>Increase: turns taken</td>
</tr>
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<td>Dada &amp; Alant (2009) Multiple baseline, (probe)</td>
<td>3 f, 1m w/ CP, DS (8-12)</td>
<td>Arts and crafts, food prep, story time w/ clinician in school</td>
<td>Rec. vocabulary</td>
<td>Aided language stimulation intervention with 3 to 5 AAC models of each target vocabulary word with paper board</td>
<td>Increase: rec. vocabulary</td>
</tr>
<tr>
<td>Studies and design</td>
<td>Subjects, gender, disability, (age)</td>
<td>Context, setting</td>
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<td>Romski, Sevcik, Adamson, Cheslock, Smith, Barker, &amp; Bakeman (2010) Group</td>
<td>43 m, 19 f w/ dev. delays (2;0 - 3;0)</td>
<td>Play, book reading, snack with clinicians, parent in clinic + home</td>
<td>Turn taking, vocabulary</td>
<td>AAC modeling condition and AAC prompting condition, both with SGD, Speech only condition</td>
<td>Increase: AAC word use for both AAC conditions</td>
</tr>
<tr>
<td>Binger, Kent-Walsh, Ewing, &amp; Taylor (2010) Multiple baseline, (probe)</td>
<td>2m, 1f w/ dev. delay, dysarthria, CP (4;6, 5;8, 6;4)</td>
<td>Story book reading w/ educational assistant in school</td>
<td>Combining words</td>
<td>Read, Ask, Answer, Prompt intervention with AAC modeling of up to 3 multi-symbol models per page spread with SGD</td>
<td>Increase: combining words</td>
</tr>
<tr>
<td>Kent-Walsh, Binger, &amp; Hasham, (2010) Multiple baseline, (probe)</td>
<td>2 f, 4 m w/ DS, CP (4;7 - 8)</td>
<td>Story book reading w/ parent in home</td>
<td>Turn taking, vocabulary</td>
<td>Read, Ask, Answer intervention with AAC modeling of up to 3 models per page spread with SGD</td>
<td>Increase: turns taken, exp. vocabulary</td>
</tr>
<tr>
<td>Kent-Walsh, Binger, &amp; Malani (2010) Within-subjects group</td>
<td>7 m, 3 f w/ autism, CP, DS, CAS (3;8 - 7;1)</td>
<td>Story book reading w/ parent in summer camp</td>
<td>Combining words</td>
<td>Read, Ask, Answer intervention with AAC modeling of up to 3 multi-symbol models per page spread with SGD</td>
<td>Increase: combining words</td>
</tr>
<tr>
<td>Binger, Maguire-Marshall, &amp; Kent-Walsh (2011) Multiple baseline, (probe)</td>
<td>(2m, 1f) w/ CP, CAS (11,9,6)</td>
<td>Story book reading w/ clinician in clinic</td>
<td>Morphology</td>
<td>AAC modeling and AAC recasting intervention with a minimum 10 AAC models of target morphologic structures with SGD</td>
<td>Increase: Aux + main verb + -ing, poss. 's, 3rd per. sing. -s, reg. past tense -ed, pl. -s</td>
</tr>
</tbody>
</table>

Table 1. Aided Language Stimulation with Individuals with Complex Communication Needs. m = male, f = female, CP = cerebral palsy, CAS = childhood apraxia of speech, DD = developmental disabilities, DS = Down syndrome,

1 Total duration, length of session, frequency
Ultimately, nine studies were categorized as conclusive based on the consideration of the 20 quality indicators from Horner et al. (2005) and the certainty of evidence categories adapted from Millar et al. (2006) and therefore included in the meta-analysis. Inter-rater reliability agreement levels for the total of the 20 quality indicators and the certainty of evidence estimation were calculated for 100% of the studies. The agreement level for the certainty of evidence estimation was 92.9% and the Kappa .85, well above the generally accepted >.7 level (Kazdin, 2011). There was only one disagreement, on Rosa-Lugo & Kent-Walsh (2008), which was controversial because it only included two tiers in the multiple baseline design. The study was ultimately included as conclusive because it was a direct replication of the Kent-Walsh, Binger, and Hasham (2010) study. A 88.8% agreement level was found overall for the 20 quality indicators and certainty of evidence estimations combined and a Cohens’ kappa of .63, within acceptable limits, especially considering the disagreements were primarily due to the lack of detailed descriptions across the quality indicators and disagreements did not negatively impact the certainty of evidence agreement (Kazdin, 2011). Following the independent analysis and comparison for inter-rater reliability, a discussion about each disagreement was conducted. This led to 100% agreement for the quality indicators and for the certainty of evidence decision.

**Participants**

The nine studies resulted in a data set of 31 participants, including a total of 70 demonstrations or tiers in the multiple baseline designs. (See Table 2) The age of the individuals represented ranged from 2 years, eleven months to 12 years, one month, with a mean age of 5 years, 9 months, and a median age of 5 years. Most of the participants, n = 21, were under 6 years old, while a smaller portion n = 10 were aged 6 through 12 years. The children had a variety of disabilities including nine children with cerebral palsy, seven children with Down syndrome, and 15 children with other disabilities such as autism, developmental disabilities, childhood apraxia of speech, cystic hygroma, velopharyngeal insufficiency, DiGeorge syndrome, and Prader-Willi
syndrome. (See Table 2)

Outcomes of Interventions

Results indicate evidence for four types of skills impacted by intervention including pragmatic, semantic, syntactic, and morphological skills. (See Tables 2 and 3)

**Pragmatic skills.** Pragmatics interventions generally target functions of language such as requesting, greeting, and labeling, and conversational skills such as turn taking, contingent responding, and storytelling (O’Neil, 2007; Prutting & Kittchner, 1987). Two studies (Binger, & Hasham, 2010; Rosa-Lugo & Kent-Walsh, 2008) directly impacted pragmatic skills by targeted increasing the frequency of communicative turns using AAC (specifically SGDs) as a primary dependent variable. (See Tables 1 and 2) Both studies used nearly identical designs and interventions, and included a total of eight participants ranging from 4 to 8 years old. Researchers taught parents to use the cognitive strategy “Read, ask, and answer” with their children. In the approach, the partner models AAC symbol use during each of the three steps for each page spread in the book, incorporates time delay (e.g. Halle, Baer, and Spradlin, 1981) between each step, and provide a contingent response to any child attempts at communication with Rosa Lugo and Kent-Walsh (2008) specifically calling for an AAC model of at least one symbol during that response. The six children in Kent-Walsh, Binger, and Hasham (2010), across two groups of three children and two children in Rosa-Lugo and Kent Walsh (2010) all had 100% PND and PEM. The mean difference in the gains of communicative turns from baseline to intervention ranged from 2 to 12 turns to as high as 3 to 50.9 turns. Kent-Walsh, Binger, and Hasham (2010) had an average mean difference of 33.3 turns, SMD = 21.4, and Rosa-Lugo and Kent-Walsh (2008) had an average mean difference of 39.6 turns, SMD = 16.

**Semantic skills.** Semantics interventions may target vocabulary development (Roseberry-McKibbin, 2007). Three studies (Dada & Alant, 2009; Drager et al., 2006; Harris & Reichle, 2004) demonstrated results of increased vocabulary knowledge across nine participants ranging
from 3 to 12 years old, which because they were multiple baseline multiple probe designs across activities provided 42 demonstrations/replications of the impact of the interventions. (See Tables 1 and 2) Drager et al. (2006), working with two children with autism, and Harris & Reichle (2004), working with three children with developmental disabilities, targeted 12 vocabulary words (mostly nouns) during a play based intervention. Four vocabulary words were targeted per activity. For example, words such as “boy”, “girl”, “desk”, “car”, “bed”, “apple”, and “dishcloth” were modeled by pointing to the object and then the AAC symbol on a paper communication display and saying the word within two seconds. Dada & Alant (2009), in the context of a group activity with 4 participants with cerebral palsy and down syndrome, took a similar approach of targeting a fixed set of vocabulary words (8 per activity), but also emphasized the AAC modeling of other words used during the activities in addition to the target vocabulary. For these three studies, the independent variables include interactive activities (e.g. play, crafts), which make them package interventions that could include elements such as prompts in the form of questions or instances of time delay. It is difficult to determine the role of these components of the interventions and how they potentially interact with the independent variable.

All three studies reported relatively similar positive effects using vocabulary probes as a primary dependent variable. Dada and Alant, probing for receptive vocabulary knowledge, reported the strongest effects out of the three, with 80% PND, 81% PEM, and mean gains of receptive vocabulary from baseline to intervention ranging across participants from 0.3 to 4 probes correct out of 8 to as high as 0 to 6.7 probes correct out of 8. Dada and Alant reported a mean difference of 5.1 probes or a 63.8% gain, SMD =17.7. An additional factor indicating this was the most effective intervention was that the results were obtained in the shortest time frame, only three sessions per target word set.

Drager et al. (2006) and Harris and Reichle (2004) probed both for receptive and expressive vocabulary. Drager et al. reported an average of 79% PND, 81% PEM overall. For
receptive vocabulary Drager et al. reported 81% PND, 86% PEM, mean gains from baseline to intervention ranging from 0.2 to 4 correct probes out of eight to as high as 1.1 to 7.8 correct probes out of eight, and a mean difference of 4.7, SMD = 6.9. For expressive vocabulary, Drager et al. reported 76% PND, 76% PEM, mean gains ranging from a low of 0 to 1.5 correct probes out of eight to as high as 0 to 7.7, and a mean difference of 3.5, SMD = 15.5.

Harris and Reichle (2004) reported similar results, with an average of 86% PND, 93% PEM overall. For receptive vocabulary, Harris and Reichle scored 85% PND, 97% PEM, with mean gains fluctuating from 0% to 50% to as high as 11.7% to 85.9% probes correct out of eight, and a mean difference of 50.5%, SMD = 5.8. For expressive vocabulary, they reported 86% PND, 86% PEM, mean gains stretching from 9.7% to 40.6% to as high as 23.3% to 82.5% probes correct of eight, and a mean difference of 55%, SMD = 4.85.

The overlapping data and lower SMD scores in the intervention condition versus the maintenance conditions represented across this data set indicates that learners acquired the vocabulary gradually, often scoring very low on the initial probes after intervention began. The difference in level changes from baseline to intervention versus baseline to maintenance demonstrate scores rising to higher levels in the final data collection sessions.

**Syntax skills.** Syntax interventions may target word order or expanding utterance length and complexity (Roseberry-McKibbin, 2007). Three studies demonstrated evidence of gains in syntax in the form of increasing multi-symbol utterances across 11 participants, aged 2 to 5 with various disabilities in the context of play (Binger & Light, 2007) and shared storybook reading (Binger et al., 2008; Binger et al., 2010). (See Tables 2 and 3) Binger and Light (2007) used a play based intervention where multi-symbol AAC models occurred a minimum of 30 times during the 15-min activity. Binger et al. (2008) and Binger et al. (2010) both used the similar cognitive strategy “Read, ask, and answer”, as found in Kent-Walsh, Binger, and Hasham (2010) and Rosa-Lugo & Kent-Walsh (2008). Yet in this version of the approach, the communication
partner, a parent in Binger et al. (2008) and an educational assistant in Binger et al. (2010), models multi-symbol AAC utterances during each of the three steps for each page spread in the book, incorporates time delays between each step, and responds to any child attempts at communication, proving multi-symbol AAC models during the response. Additionally, Binger et al. (2010) adds an optional prompt step at the end of the strategy where a verbal prompt can be provided.

The impact of these syntax interventions was consistently positive with high effect sizes across eight of nine participants. In response to the play based intervention Binger and Light (2007) reported 94% PND and 99% PEM overall. The mean gain from baseline to intervention was relatively low for one participant, 0.7 to 4.2 multi-symbol utterances, but ranged to as high as 1.7 to 20.2 multi-symbol utterances. The mean difference for the child who scored lowest was only 3.5, SMD = 4.3, which was much lower than the overall average for the study, 11.6, SMD = 14.1. See Table 2 for the range of individual participant data.

Binger et al. (2008) and Binger et al. (2010), which used similar interventions and designs, produced nearly identical strong effect sizes. Binger et al. (2008) reported 88% PND, 100% PEM, and Binger et al. (2010) reported 96% PND, 100% PEM. The two studies mean gains ranged from 0.5 to 9.8 to as high as 0 to 12 multi-symbol utterances. The SMD’s only differed by a tenth of a point. Binger et al. (2008) reported a mean difference of 10.1, SMD = 7.6, while Binger et al. (2010) reported 9.9, SMD = 7.5.

**Morphology skills.** Morphology interventions may target word inflections (Roseberry-McKibbin, 2007). One study (Binger et al., 2011) provided evidence of gains in morphology development with three participants and a total of nine demonstrations in the multiple baseline across activities design. (See Tables 2 and 3) In the context of book reading, Binger et al. (2011) studied the acquisition of morphemes such as “plural -S”, “present progressive -ING”, “past tense -ED”, and “possessive ‘S’”. The intervention included AAC models and recasts with the target
forms (e.g. modeling on the SGD: HE IS GO + ING). All three participants quickly improved their performance in the probes of each of the target forms with overall robust changes in level from baseline to the total of probe sessions, reporting 92% PND and 93% PEM. They reported mean gains ranging from a low of 13% to 62% to as high as 0% to 100% probes correct, and a mean difference of 77%, SMD = 13.4.

**Independent variable packages.** Due to the nature of the interventions being interactive communication experiences, all studies independent variables were package interventions. Six of the studies explicitly stated that they included specific intervention package components including AAC modeling, question asking, time delay, and responding to child communication attempts. Three of the remaining studies provided more general descriptions of the activities.
Table 2. Participant level information and outcomes for studies presenting the “best evidence” related to AAC modeling based interventions

<table>
<thead>
<tr>
<th>Study, Design, Int ID</th>
<th>Gen, age, dis</th>
<th># of sess</th>
<th>Int Note</th>
<th>PND, PEM</th>
<th>MD, SMD</th>
<th>PND, PEM</th>
<th>MD, SMD</th>
<th>PND, PEM</th>
<th>MD, SMD</th>
<th>Mean Gain base to int total</th>
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<tbody>
<tr>
<td><strong>Taking communicative turns with AAC</strong></td>
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<tr>
<td>A F, 8, CP</td>
<td>8</td>
<td>100, 9, 100, 10.5, 100, 10.7, 100, 10, 2 to 12 turns</td>
<td>100, 5.8, 100, 6.7, 100, 6.8, 100, 6.4</td>
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<tr>
<td>B M, 5;4, DS</td>
<td>8</td>
<td>100, 40.3, 100, 42.7, 100, 47.7, 100, 43.7, 2.3 to 46 turns</td>
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<tr>
<td>C F, 5;0, CP</td>
<td>8</td>
<td>100, 27.7, 100, 29.8, 100, 31.3, 100, 29.6, 9.7 to 39.3 turns</td>
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<tr>
<td>D M, 8;3, CP</td>
<td>7</td>
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<td>100, 14.6, 100, 17.2, 100, 22.7, 100, 17.6</td>
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<tr>
<td>E M, 4;7, DS</td>
<td>5</td>
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<td>100, 33.8, 100, 28.4, 100, 30.7</td>
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<tr>
<td>F M, 5;1, DS</td>
<td>7</td>
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<td>A F, 6;10, Cystichygroma</td>
<td>9</td>
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<td>100, 11.3, 100, 10.9, 100, 17.8, 100, 13.3</td>
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<td><strong>MBD - P, Int. same as Kent-Walsh et al., (2010)</strong></td>
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<tr>
<td>B M, 6;8, DD</td>
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<td>100, 19.1, 100, 18.1, 100, 18.6</td>
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<td>MD, SMD</td>
<td>PND, PEM</td>
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<tr>
<td>A  M, 8;6, CP</td>
<td>3</td>
<td>Arts and crafts</td>
<td>67, 67</td>
<td>4.3, 15.1</td>
<td>NA, NA</td>
<td>100, 100</td>
<td>7.8, 27.4</td>
<td>89, 89</td>
<td>6.7, 23.3</td>
<td>Demonstrating receptive and expressive vocabulary knowledge</td>
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<td>3</td>
<td>Food prep</td>
<td>67, 67</td>
<td>4.5, 15.7</td>
<td>NA, NA</td>
<td>100, 100</td>
<td>7.5, 26.2</td>
<td>83, 83</td>
<td>6, 21</td>
<td>0 to 6.7 rec. probes correct of 8</td>
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<tr>
<td></td>
<td>3</td>
<td>Story time</td>
<td>67, 67</td>
<td>4.2, 14.7</td>
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<td>NA, NA</td>
<td>67, 67</td>
<td>4.2, 14.7</td>
<td>0 to 4.3 rec. probes correct of 8</td>
<td></td>
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<tr>
<td>B  F, 10;1, CP</td>
<td>3</td>
<td>Arts and crafts</td>
<td>100, 100</td>
<td>4, 14</td>
<td>NA, NA</td>
<td>100, 100</td>
<td>6.7, 23.3</td>
<td>100, 100</td>
<td>5.8, 20.2</td>
<td>0 to 5.8 rec. probes correct of 8</td>
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<td>3</td>
<td>Food prep</td>
<td>67, 67</td>
<td>4.2, 14.6</td>
<td>NA, NA</td>
<td>100, 100</td>
<td>6.5, 22.7</td>
<td>83, 83</td>
<td>5.3, 18.6</td>
<td>0 to 5.5 rec. probes correct of 8</td>
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<tr>
<td></td>
<td>3</td>
<td>Story time</td>
<td>67, 67</td>
<td>3.7, 12.8</td>
<td>NA, NA</td>
<td>NA, NA</td>
<td>67, 67</td>
<td>3.7, 12.8</td>
<td>0.3 to 4 rec. probes correct of 8</td>
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<tr>
<td>C  F, 8;1, CP</td>
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<td>Arts and crafts</td>
<td>67, 67</td>
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<td>100, 100</td>
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<td>0 to 5.8 rec. probes correct of 8</td>
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<td>3</td>
<td>Food prep</td>
<td>67, 100</td>
<td>4.8, 16.9</td>
<td>NA, NA</td>
<td>100, 100</td>
<td>7.8, 27.4</td>
<td>83, 100</td>
<td>6.3, 22.1</td>
<td>0.2 to 6.5 rec. probes correct of 8</td>
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<td></td>
<td>3</td>
<td>Story time</td>
<td>67, 67</td>
<td>3.3, 11.6</td>
<td>NA, NA</td>
<td>NA, NA</td>
<td>67, 67</td>
<td>3.3, 11.6</td>
<td>0 to 3.3 rec. probes correct of 8</td>
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<td># of sess</td>
<td>Int Note</td>
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<td>D F, 12;1, DS</td>
<td>3</td>
<td>3</td>
<td>Arts and crafts</td>
<td>33, 33</td>
<td>1, 3.5</td>
<td>NA NA</td>
<td>100, 100</td>
<td>5.7, 19.8, 14.4</td>
<td>0 to 4.1 rec. probes correct of 8</td>
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<td>3</td>
<td>Food prep</td>
<td>67, 67</td>
<td>4.8, 16.9</td>
<td>NA NA</td>
<td>100, 100</td>
<td>6.5, 83</td>
<td>5.7, 19.8</td>
<td>0.2 to 5.8 rec. probes correct of 8</td>
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<td>3</td>
<td>Story time</td>
<td>67, 67</td>
<td>3.9, 13.6</td>
<td>NA NA</td>
<td>NA NA</td>
<td>67, 67</td>
<td>3.9, 13.6</td>
<td>0 to 6.7 rec. probes correct of 8</td>
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<tr>
<td>Drager, Postal, Carrolus, Castellano, Gagliano, &amp; Glynn (2006), MBD-A, play w/ clinician, 4 AAC models of each target vocabulary word w/ paper board</td>
<td>M F, 4;5, autism</td>
<td>13</td>
<td>Dollhouse rec.</td>
<td>90, 90</td>
<td>4.4, 6.5</td>
<td>NA NA</td>
<td>100, 100</td>
<td>6.7, 92</td>
<td>4.9, 7.3</td>
<td>0 to 4.9 rec. probes correct of 8</td>
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<td></td>
<td></td>
<td></td>
<td>Dollhouse exp.</td>
<td>60, 60</td>
<td>1.4, 6.1</td>
<td>NA NA</td>
<td>67, 67</td>
<td>1.7, 62</td>
<td>1.5, 6.4</td>
<td>0 to 1.5 exp. probes correct of 8</td>
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<td></td>
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<td>School rec.</td>
<td>67, 100</td>
<td>3, 4.4</td>
<td>NA NA</td>
<td>100, 100</td>
<td>7.1, 73</td>
<td>3.8, 5.6</td>
<td>0.2 to 4 rec. probes correct of 8</td>
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<td></td>
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<td>School exp.</td>
<td>75, 75</td>
<td>1.8, 7.7</td>
<td>NA NA</td>
<td>100, 100</td>
<td>6, 80</td>
<td>2.6, 11.4</td>
<td>0 to 2.6 exp. probes correct of 8</td>
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<td>Playgroun exp.</td>
<td>60, 60</td>
<td>3.8, 7.9</td>
<td>NA NA</td>
<td>60, 60</td>
<td>3.8, 80</td>
<td>3.8, 5.6</td>
<td>0.6 to 4.4 rec. probes correct of 8</td>
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<td>Playgroun exp.</td>
<td>60, 60</td>
<td>1.8, 7.9</td>
<td>NA NA</td>
<td>60, 60</td>
<td>1.8, 7.9</td>
<td>0.4 to 2.2 rec. probes correct of 8</td>
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<td>Cars rec.</td>
<td>54, 69</td>
<td>3, 4.5</td>
<td>NA NA</td>
<td>100, 100</td>
<td>7.5, 75</td>
<td>3.9, 5.7</td>
<td>0.5 to 4.4 rec. probes correct of 8</td>
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<td>Gen, age, dis</td>
<td># of sess</td>
<td>Int Note</td>
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<td>Mean Gain base to int total</td>
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<td>MD, SMD</td>
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<td>NA</td>
<td>100, 100</td>
<td>8, 35.1</td>
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<td>6 Dollhouse rec.</td>
<td>100, 100</td>
<td>6.6, 9.7</td>
<td>NA</td>
<td>NA</td>
<td>100, 100</td>
<td>6.9, 10.2</td>
<td>100, 100</td>
<td>6.7, 10</td>
<td>0 to 7.8 rec. probes correct of 8</td>
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<td>Dollhouse exp.</td>
<td>100, 100</td>
<td>7.5, 33.1</td>
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<td>NA</td>
<td>100, 100</td>
<td>6.9, 10.2</td>
<td>100, 100</td>
<td>7.7, 33.6</td>
<td>0 to 7.7 exp. probes correct of 8</td>
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<tr>
<td>5 Playground rec.</td>
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<td>5.1, 7.5</td>
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<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>100, 100</td>
<td>5.1, 7.5</td>
<td>0.8 to 5.8 rec. probes correct of 8</td>
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<td>Playground exp</td>
<td>100, 100</td>
<td>5, 21.9</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>100, 100</td>
<td>5, 21.9</td>
<td>0 to 5 exp. probes correct of 8</td>
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<tr>
<td>Harris &amp; Reichle (2004), MBD - A, play w/ teacher, 4 AAC models of each target vocabulary word w/ paper board</td>
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<td></td>
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<tr>
<td>Food rec.</td>
<td>64, 100</td>
<td>28.3, 3.2</td>
<td>NA</td>
<td>NA</td>
<td>60, 100</td>
<td>31.8, 3.6</td>
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<td>28.9, 3.3</td>
<td>23.2% to 52.1% rec. probes correct of 8</td>
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<tr>
<td>Food exp.</td>
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<td>39.8, 2.6</td>
<td>NA</td>
<td>NA</td>
<td>100, 100</td>
<td>72.5, 4.8</td>
<td>94, 100</td>
<td>50, 3.3</td>
<td>0% to 50% exp. probes correct of 8</td>
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<tr>
<td>Furniture rec.</td>
<td>57, 90</td>
<td>28.2, 3.2</td>
<td>NA</td>
<td>NA</td>
<td>100, 100</td>
<td>53.8, 6.1</td>
<td>92, 31.4</td>
<td>3.6</td>
<td>29.5% to 60.9% rec. probes correct of 8</td>
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<tr>
<td>Furniture exp.</td>
<td>50, 83</td>
<td>31.8, 2.1</td>
<td>NA</td>
<td>NA</td>
<td>100, 100</td>
<td>79.7, 5.3</td>
<td>67, 89</td>
<td>47.7, 3.2</td>
<td>20.3% to 68.1% exp. probes correct of 8</td>
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<tr>
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<td>ID</td>
<td>Gen, age, dis</td>
<td># of sess</td>
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<td>Gen</td>
<td>Main</td>
<td>Total</td>
<td>Mean Gain base to int total</td>
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<td></td>
<td></td>
<td>PND, PEM</td>
<td>MD, SMD</td>
<td>PND, PEM</td>
<td>MD, SMD</td>
<td>PND, PEM</td>
<td>MD, SMD</td>
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<tr>
<td></td>
<td>17</td>
<td></td>
<td></td>
<td>Body parts rec.</td>
<td>93, 93</td>
<td>50.9, 5.8</td>
<td>NA</td>
<td>NA</td>
<td>100, 100</td>
<td>83.3, 94</td>
</tr>
<tr>
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<td></td>
<td>Body parts exp.</td>
<td>40, 40</td>
<td>17.8, 1.2</td>
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<td>NA</td>
<td>100, 100</td>
<td>52.8, 62</td>
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<tr>
<td>N M, 5;4, DS</td>
<td>29</td>
<td>Tools rec.</td>
<td>81, 92</td>
<td>29.4, 3.4</td>
<td>NA</td>
<td>NA</td>
<td>100, 100</td>
<td>72.7, 83</td>
<td>83, 33.9</td>
<td>33.9, 3.9</td>
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<td>Tools exp.</td>
<td>87.5, 100</td>
<td>42.9, 2.8</td>
<td>NA</td>
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<td>100, 100</td>
<td>65.3, 91</td>
<td>91, 49</td>
<td>49, 3.3</td>
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<tr>
<td></td>
<td>15</td>
<td>Vehicles rec.</td>
<td>92, 92</td>
<td>54.8, 6.3</td>
<td>NA</td>
<td>NA</td>
<td>100, 100</td>
<td>76.7, 93</td>
<td>93, 59.2</td>
<td>59.2, 6.8</td>
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<td>Vehicles exp.</td>
<td>60, 83</td>
<td>41.9, 2.8</td>
<td>NA</td>
<td>NA</td>
<td>100, 100</td>
<td>71.9, 75</td>
<td>75, 53.1</td>
<td>53.1, 3.5</td>
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<tr>
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<td>Food rec.</td>
<td>93, 100</td>
<td>53.3, 6.1</td>
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<td>NA</td>
<td>100, 100</td>
<td>64, 94</td>
<td>94, 55.2</td>
<td>55.2, 6.3</td>
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<tr>
<td></td>
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<td>Food exp.</td>
<td>83, 100</td>
<td>73.4, 4.9</td>
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<td>NA</td>
<td>100, 100</td>
<td>75.5, 89</td>
<td>89, 74.1</td>
<td>74.1, 4.9</td>
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<td># of sess</td>
<td>Int Note</td>
<td>PND, MD, SMD</td>
<td>Gen, MD, SMD</td>
<td>Main, PND, MD, SMD</td>
<td>Total, MD, SMD</td>
<td>Mean Gain base to int total</td>
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<tr>
<td>E F, 4;2, DD</td>
<td>31</td>
<td>Tools rec.</td>
<td>100, 56.9</td>
<td>NA NA</td>
<td>100, 90.6</td>
<td>100, 61.3</td>
<td>9.4% to 70.7% rec. probes correct of 8</td>
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<td>Tools exp.</td>
<td>100, 68.8</td>
<td>NA NA</td>
<td>100, 88.8</td>
<td>100, 74.8</td>
<td>6.3% to 81% rec. probes correct of 8</td>
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<tr>
<td>8</td>
<td>Food rec.</td>
<td>80, 65.8</td>
<td>100, 10.1</td>
<td>80, 74.2</td>
<td>80, 110.1</td>
<td>8.5</td>
<td>11.7% to 85.9% rec. probes correct of 8</td>
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<tr>
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<td>Food exp.</td>
<td>100, 82.3</td>
<td>100, 5.5</td>
<td>100, 82.3</td>
<td>100, 82.3</td>
<td>100, 5.5</td>
<td>17.7% to 100% exp. probes correct of 8</td>
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<tr>
<td>9</td>
<td>Cleaning items rec.</td>
<td>83, 46.9</td>
<td>100, 7.7</td>
<td>100, 67.7</td>
<td>100, 67.7</td>
<td>100, 5.4</td>
<td>24% to 77.8% rec. probes correct of 8</td>
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<td>Cleaning items exp.</td>
<td>100, 46.4</td>
<td>100, 5.3</td>
<td>100, 79.8</td>
<td>100, 79.8</td>
<td>100, 4.4</td>
<td>16.1% to 82.5% exp. probes correct of 8</td>
<td></td>
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</table>

**Combining words to form multi-symbol utterances with AAC**

- **Binger & Light (2007), MBD - P, Play w/ clinician, minimum of 30 multi-symbol AAC models w/ paper board or SGD**
  - V F, 4;3, Prader-Willi | 9 | SGD | 100, 11.8 | 100, 12.5 | 100, 10.5 | 100, 11.5 | 4.5 to 16 multi-symbol utterances |
  - T M, 3;5, DiGeorge S. | 12 | SGD | 100, 16.4 | 100, 18.3 | 100, 23.3 | 100, 18.5 | 1.7 to 20.2 multi-symbol utterances |
- **R F, 4;6, DS** | 29 | Add. cond., SGD, Paper | 86, 3.5 | 86, 3.5 | 86, 3.5 | 86, 3.5 | 0.7 to 4.2 multi-symbol utterances |
<table>
<thead>
<tr>
<th>Study, Design, Int ID</th>
<th>Gen, age, dis</th>
<th># of sess</th>
<th>Int Note</th>
<th>PND, PEM</th>
<th>MD, SMD</th>
<th>Int</th>
<th>Gen</th>
<th>Main</th>
<th>Total</th>
<th>Mean Gain base to int total</th>
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</thead>
<tbody>
<tr>
<td>N M, 4:4, DD, s. CAS</td>
<td>22 Paper</td>
<td></td>
<td></td>
<td>100, 12</td>
<td>100, 14.6</td>
<td>100, 16</td>
<td>100, 19.4</td>
<td>100, 13.4</td>
<td>1 to 12.1 multi-symbol utterances</td>
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</tr>
<tr>
<td>R M, 4:2, DD, s. CAS</td>
<td>17 Paper</td>
<td></td>
<td></td>
<td>70, 8.1</td>
<td>100, 23.9</td>
<td>100, 22.3</td>
<td>100, 27.1</td>
<td>100, 16.4</td>
<td>0.3 to 13.8 multi-symbol utterances</td>
<td></td>
</tr>
<tr>
<td>Binger, et al., (2008) A M, 4:1, phon. proc. dis.</td>
<td>10</td>
<td></td>
<td></td>
<td>100, 10.7</td>
<td>100, 10.3</td>
<td>100, 12.3</td>
<td>100, 11.1</td>
<td>2.3 to 13.4 multi-symbol utterances</td>
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<tr>
<td>MBD - P, Storybook reading w/ parent, AAC modeling up to 3 multi-symbol models per page spread w/ read, ask, answer strategy with SGD</td>
<td>A F, 3:4, s. VCFS, p. VPI, s. CAS</td>
<td>16</td>
<td></td>
<td>64, 6.8</td>
<td>100, 16</td>
<td>100, 14.2</td>
<td>75, 9.3</td>
<td>0.5 to 9.8 multi-symbol utterances</td>
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</tr>
<tr>
<td>Binger, Kent-Walsh, Ewing, &amp; Taylor (2010) MBD - P, Storybook reading w/ EA, AAC modeling up to 3 multi-symbol models per page spread w/ read, ask, answer, prompt strategy w/ SGD</td>
<td>J F, 2:11, Subp. cleft, p. VPI</td>
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<td>100, 8.8</td>
<td>100, 11.3</td>
<td>90, 9.8</td>
<td>1.2 to 11 multi-symbol utterances</td>
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<td>O M, 6:4, DD</td>
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<td>100, 11.3</td>
<td>100, 14.5</td>
<td>100, 11</td>
<td>100, 12</td>
<td>0 to 12 multi-symbol utterances</td>
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<td>A M, 4:6, DD, s. CAS</td>
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<td>100, 8.5</td>
<td>100, 10</td>
<td>100, 10.5</td>
<td>100, 9.2</td>
<td>0 to 9.2 multi-symbol utterances</td>
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<td>V F, 5:8, Dysarthria, CP</td>
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<td>100, 7</td>
<td>100, 12.5</td>
<td>89, 8.6</td>
<td>0 to 8.6 multi-symbol utterances</td>
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<tr>
<td>Study, Design, Int ID</td>
<td>Gen, age, dis</td>
<td># of sess</td>
<td>Int Note</td>
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<td>Gen</td>
<td>Main</td>
<td>Total</td>
<td>Mean Gain base to int total</td>
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<tr>
<td>Binger, Maguire- Marshall, &amp; Kent-Walsh (2011) MBD-A, Story book reading w/ clinician, Aided AAC models and recasts: grammatically complete spoken messages plus messages produced on the SGD that contained the targeted morpheme(s). Minimum 10 per session.</td>
<td>A M, 11, CP</td>
<td>15</td>
<td>Aux + main verb + -ing, Add. cond. 2</td>
<td>92, 100</td>
<td>53, 9.1</td>
<td>NA</td>
<td>NA</td>
<td>50, 50</td>
<td>22, 3.8</td>
<td>87, 93</td>
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<td>Possessive 's</td>
<td>100, 100</td>
<td>100, 17.3</td>
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<td>NA</td>
<td>100, 100</td>
<td>100, 100</td>
<td>100, 100</td>
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<td>3rd person singular +s</td>
<td>100</td>
<td>88</td>
<td>NA</td>
<td>NA</td>
<td>100</td>
<td>90</td>
<td>100</td>
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<td></td>
<td>13</td>
<td>Possessive 's Add. cond. 2</td>
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<td>62.2, 10.8</td>
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<td>NA</td>
<td>75</td>
<td>75</td>
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<td></td>
<td></td>
<td>13</td>
<td>Regular past tense +ed, Add. cond. 2</td>
<td>89</td>
<td>75.6</td>
<td>NA</td>
<td>NA</td>
<td>100</td>
<td>90</td>
<td>92</td>
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<td>Plural +s</td>
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<td>I M, 9, CP</td>
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<td>100</td>
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<td>Aux + main verb + -ing</td>
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<td>80</td>
<td>NA</td>
<td>NA</td>
<td>100</td>
<td>80</td>
<td>100</td>
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</table>
Note. Int: Intervention, Gen: Gender, dis: disability, sess.: sessions, PND: Percentage of non-overlapping data, PEM, Percentage non-overlapping data exceeding the median, MD: Mean difference, SMD: Busk & Serlin (1993) standard mean difference, MBD: Multiple baseline multiple probe design, -P: Across participants, -A: Across activities, Additional conditions: 1) switch to paper board, plus alt. activities and Multi-modal models, 2: Additional intervention phase that included contrastive targets and additional maintenance following that phase. CP: cerebral palsy, CAS: childhood apraxia of speech, s.: suspected, DS: Down Syndrome.
Table 3. *Study level data and totals*

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>Dem</th>
<th>PND</th>
<th>PEM</th>
<th>MD</th>
<th>SMD</th>
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<td><strong>Taking communicative turns with AAC</strong></td>
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<tr>
<td>Kent-Walsh, Binger, &amp; Hasham, (2010)</td>
<td>6</td>
<td>6</td>
<td>100%</td>
<td>100%</td>
<td>33.3</td>
<td>21.4</td>
</tr>
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<td>Rosa-Lugo &amp; Kent-Walsh, (2008)</td>
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<td>2</td>
<td>100%</td>
<td>100%</td>
<td>39.6</td>
<td>16</td>
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<tr>
<td><strong>Demonstrating receptive and expressive vocabulary knowledge</strong></td>
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<tr>
<td>Dada &amp; Alant (2009)</td>
<td>4</td>
<td>12</td>
<td>80%</td>
<td>81%</td>
<td>63.8%</td>
<td>17.7</td>
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<tr>
<td>Drager, et al., (2006)</td>
<td>2</td>
<td>12</td>
<td>79%</td>
<td>81%</td>
<td>51.3%</td>
<td>11.2</td>
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<tr>
<td>Harris &amp; Reichle (2004)</td>
<td>3</td>
<td>18</td>
<td>86%</td>
<td>93%</td>
<td>55%</td>
<td>4.85</td>
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<td><strong>Combining words to form multi-symbol utterances with AAC</strong></td>
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<tr>
<td>Binger &amp; Light (2007)</td>
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<td>5</td>
<td>94%</td>
<td>99%</td>
<td>11.6</td>
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<td>Binger, et al., (2008)</td>
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<td>3</td>
<td>88%</td>
<td>100%</td>
<td>10.1</td>
<td>7.6</td>
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<tr>
<td>Binger, et al., (2010)</td>
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<td>3</td>
<td>96%</td>
<td>100%</td>
<td>9.9</td>
<td>7.5</td>
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<td><strong>Using morphology structures with AAC</strong></td>
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<tr>
<td>Binger et al., (2011)</td>
<td>3</td>
<td>9</td>
<td>92%</td>
<td>93%</td>
<td>77%</td>
<td>13.4</td>
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<td>Total</td>
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<td>70</td>
<td>90.6%</td>
<td>94.1%</td>
<td>NA</td>
<td>12.6</td>
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</tbody>
</table>

*Note.* Dem = Demonstrations/replications in the multiple baseline designs
Discussion

Overall, across 9 studies, 31 participants, and 70 demonstrations, the research investigating the impact of aided AAC modeling based interventions reported consistently positive main effects for pragmatic, semantic, syntactic, and morphological development. The results provide evidence that when provided with appropriate models of the use of AAC within naturalistic contexts and various interaction techniques such as time delay, the learners made observable gains in both expressive and receptive language. Reinforcing the findings, AAC modeling in augmentative communication intervention is well aligned with major language acquisition theories regarding the importance of language input (Gerkin, 2008; Hirsh-Pasek & Golinkoff, 1996).

The ultimate goal of meta-analysis is to better determine the meaningfulness of the reported results (Busk & Serlin, 1992). In the case of this meta-analysis, quantifying participant and study level data on AAC modeling based interventions provided 70 demonstrations of the phenomena, a sizable data set in which to attempt to make inferences. The clinical question, put simply is “Do we see children like our children, and if so, are the results meaningful enough to convince us that the intervention worked?” In addition, it is essential to review the limitations of potential inferences, as well as what mitigating factors influence the results.

Participants

Presently, the AAC modeling based intervention research has primarily focused on young children (age 2-5) with CCN who can independently access an AAC system. Older school age individuals (age 6-12) were also represented. From an age comparison perspective, the focus on younger children compares to the time frame, in which motherese is typically used, in the first few years of life. Yet, the interactions found in the AAC modeling based interventions are also similar to what Tomasello (2003) described as creating a shared “common ground”, which are found occurring throughout the life course. AAC modeling based interventions had a positive impact across the range of ages represented, suggesting that it may possibly be an effective
intervention across the life span.

Yet, future research is needed to explore the exact impact at different ages, and the development of the optimal match between the skills of the individual who requires AAC and the type of AAC modeling provided. Further investigation of matching individual needs in early intervention with targeted AAC modeling interventions are a high priority due to the broad impact that the successful development of communication skills has on individuals (Light, 2003). It is also important to study older individuals, building on the initial studies not meeting criteria for the meta-analysis by Romski et al. (1994) who targeted older children, teens, and young adults, and by Beck et al. (2009) targeting adults. In future research, it would be valuable to evaluate the effects of providing AAC modeling based interventions to adults covering a range of contexts, including: (a) adults with a history of using AAC, targeting various skills and levels of skills; (b) adults who have not been provided adequate AAC in their lives, despite having CCN; and (c) other adults, such as those who may have acquired disabilities later in life.

A range of disability groups are represented in the research reviewed including those with autism, childhood apraxia of speech, cerebral palsy, and various developmental disabilities. (See Table 2) To better understand the effects of AAC modeling based interventions on individuals with complex communication needs, there is a necessity to extend the research with currently studied populations and to include a greater range of populations. For instance, Drager et al. (2006), focused on individuals with autism. The large number of individuals with autism who have difficulty speaking makes this population a high priority for extending the research. Regarding new populations to be studied, there was a lack individuals who use alternate access represented across the meta-analysis and only Goosens’ (1989), which was a case study on a girl with significant motor disabilities. This indicates a clear need for future research to include studies designed to assess participants incorporating various alternate access strategies and tools. This is of high priority, especially as these options are expanding so rapidly (ex. switch access,
eye-control access, brain-computer interfaces). Future research is needed to explore AAC modeling based interventions with other individuals with disabilities associated with CCN, such as traumatic brain injury, aphasia, ALS, and others.

**Outcomes of Interventions**

*Pragmatics.* Pragmatic language development, while an important issue in AAC, has often been under represented (Iacono, 2003). The evidence suggests that in response to AAC modeling based interventions, children with CCN can increase their frequency of communication turns as a gain in the area of pragmatic language. When the differences from baseline to intervention are evaluated closely, we see meaningful, immediate level changes and those gains sustained across generalization and maintenance phases. The mean difference scores across the studies were 33.3, SMD = 21.4 (Kent-Walsh, Binger, & Hasham, 2010) and 39.6, SMD = 16 (Rosa-Lugo & Kent-Walsh, 2008). Those scores represent meaningful differences in child communication turns, especially considering the immediacy of the gains and that the overall progress was obtained in five to nine sessions of 10 min. Future research is needed to determine how AAC modeling based interventions would work to impact additional skills in the pragmatic domain.

*Semantics.* Research indicates that users of AAC are at risk for semantic related language delays because they may be talked to less, they often are forced to rely on others for lexicon development, the asymmetry between input to output, and the difficulties surrounding the use of graphic symbol sets (Beukelman & Mirenda, 2005). The evidence supports that AAC modeling based interventions impacted vocabulary knowledge for small sets of target vocabulary words, which were mostly nouns. Across the three studies in this area (Dada & Alant, 2009; Drager et al., 2006; Harris & Reichle, 2004), vocabulary knowledge increased steadily from baseline to intervention, showing solidly consistent acquisition of the target words by the end of the studies which ranged from 3 sessions to much longer, especially in Harris and Reichle (2004). Future research is essential to investigate exactly how AAC modeling based interventions impacts a
broader range of semantic word categories. Future research is also needed to explore not just children early in the vocabulary acquisition process, but individuals with CCN who have more robust vocabularies and have need to expand them. In addition, mitigating factors could be explored, such as the role of fast mapping (Mervis & Bertrand, 1994), joint attention (Adamson, Bakeman, Deckner, & Roms, 2009), and overall scope and sequence of vocabulary learning for individuals.

**Syntax and Morphology.** Individuals who use AAC have been reported to be at risk for experiencing deficits in syntax and morphology skills (Binger & Light, 2008; Blockberger & Sutton, 2003). The impact of being able to combine words and parts of words is important, as it provides access to the generative, flexible, and combinatorial power of language. Research suggests that individuals with CCN, especially beginning communicators, often produce short telegraphic utterances (Binger & Light, 2008; Blockberger & Sutton, 2003). The evidence found in this meta-analysis indicates that in response to AAC modeling based interventions, children with CCN who require AAC were able to increase their use of multi-symbol utterances in a meaningful way in the context of play (Binger & Light, 2007) and shared storybook reading (Binger et al., 2008; 2010). Also, while only across three participants and 9 demonstrations, Binger et al. (2011) demonstrated children acquiring the use of morphology structures in response to AAC modeling and AAC recasts during shared storybook reading. Taken together, this emerging evidence in the syntax and morphology domains is an encouraging sign that when provided the right interventions, children with CCN can develop these generative, flexible, and combinatorial skills. With the broad array of skills represented in both the syntax and morphology domains, it is important for future research to discern how these skills are impacted by AAC modeling interventions.

**Cross-domain considerations.** Each of the nine studies represented in this meta-analysis had a primary domain they were concerned with. Yet, in the life of a language learner, those
domains are constantly interacting. For instance, learning to use increasingly longer utterances opens up the potential to use utterances with more sophisticated pragmatic intents. Additionally, based on the available evidence across those various domains, it is conceivable that an intervention could target multiple areas in combination, such as a set of new vocabulary words, various areas of pragmatic language, increasing multi-symbol utterances, and a specific morphology structure. Future research is needed to (a) determine if multiple skills can be successfully impacted at one time and (b) investigate potential secondary impacts of AAC modeling based interventions on a range of language skills and overall communicative competence domains.

**Mitigating Factors and Limitations**

*Limitations of the database.* It is essential to establish that though the results of this meta-analysis are positive and that there are a relatively large number of demonstrations of the phenomena (n = 70), that the evidence uses exclusively a single subject design and a restricted age and disability range. Additionally, Light (2003) described the importance of individuals with CCN developing communicative competence, including linguistic, operational, social, and strategic competencies. Much of these areas has yet to be investigated. Therefore caution should be used in interpreting these findings.

*Quality of Input.* From an intervention perspective, it is apparent that the intervention packages the children received in all of the studies, had both input and interaction components. These components are difficult, if not impossible to parse out. Therefore, it is important to specify that evidence suggests that AAC modeling based interventions, when set in the context of rich naturalistic interaction that harnesses the attention of the learner, impacted various areas of child language development. In five of the studies (Binger et al., 2008; Binger, et al., 2010; Binger et al., 2011; Kent-Walsh, Binger, & Hasham, 2010; Rosa-Lugo & Kent-Walsh, 2008) children experienced an intervention that was set in the context of shared storybook reading where the
interventionist worked to model AAC, provided wait time, asked questions, and responded to child communication, as well as low level verbal prompts (Binger et al., 2010; Kent-Walsh, Binger, & Hasham, 2010). The four other studies (Binger & Light, 2007; Dada & Alant, 2009; Drager et al., 2006, Harris & Reichle, 2004) used play, art, food preparation, or stories to create similar naturalistic interactions that engaged the learner and filled the experience with varying levels of AAC modeling. While future research designs may be able to isolate the specific impact of the modeling component, from a theoretical perspective it is logical that the language input and interaction components be delivered together (Tomasello, 2003).

**Quantity of Input.** For speaking children, parents and caregivers typically provide language input naturally (Tomasello, 2003), although clearly along a range regarding input (from 620 to 2,150 words heard per hour) (Hart & Risley, 1995). For individuals with CCN, the situation is more complicated. We know that typical interactions rarely include AAC models (Smith & Grove, 2003) and infrequently provide opportunities for expressive communication (Blockberger & Sutton, 2003). The amount and frequency of AAC modeling described across the interventions seems extraordinarily small in comparison to the input speaking children at age three are hearing, which is an average of 1,250 words per hour and 125,000 words of language experience per week (Hart & Risley, 1995). The AAC modeling research reports numbers such as 30 AAC models in 15 min (Binger & Light, 2007), or 4 models of each target vocabulary word per 15 min session (Harris & Reichle, 2004; Drager et al., 2006). The equivalent is 16 to 240 words per hour or only 1,600 to 24,000 words per week, standing in stark contrast to the massive 125,000 words per week for speaking children. Even the largest dosage of AAC modeling reported, in the longitudinal study by Romski and colleagues (1995) in which approximately 10% of the utterances (Sevcik, Romski, Watkins, & Deffebach, 1995) included an aided AAC model during select segments of the day over the span of two years, pales in comparison to the input speaking children hear. Despite the relatively small dosage of input, as compared to speaking children, the
results of AAC modeling based interventions were consistently positive across pragmatic, semantic, syntactic, and morphological domains. In the future, with the advent of near ubiquitous new mobile technologies such as the iPhone, iPod touch, and iPad serving as AAC systems, it is theoretically possible that communication partners could be able to provide a greater degree of AAC modeling throughout the day (Sennott & Bowker, 2009).

Conclusion

When asked how a parent might best support a child’s learning of language, Roger Brown (in the introduction to the seminal Snow and Ferguson, (1976, p. 26)) provided the following response: “How can a concerned mother facilitate her child’s learning of language?” His answer was, “Believe that your child can understand more than he or she can say, and seek, above all to communicate. To understand and be understood... If you concentrate on communicating, everything else will follow.” The research reviewed here is evidence that these same high expectations and the use of AAC modeling based interventions can produce benefits for individuals with CCN. The challenge is how to better provide a rich communication environment full of models of language, engagement, high expectations, and opportunities for participation. When these conditions are provided, there is good reason to think that the learning of language “…will follow”.

Appendix B

Pilot study of ModelER for Read and Talk

Language input is an important factor in language acquisition for all children (Gallway & Richards, 1994; Gerkin, 2008; Pinker, 2000; Snow & Ferguson, 1978; Tomasello, 2003). During early childhood, children using speech are exposed to a large amount of language input in the form of social interaction (Hart & Risley, 1995, Tomasello, 2003). In fact, the amount of words these children typically hear in their first four years ranges from approximately eight million to 50 million words (Hart & Risley, 1995).

Similarly to children who learn to communicate using speech, language input is important to children who use other expressive communication modalities as well, such as individuals with complex communication needs (CCN) who require augmentative and alternative communication (AAC). These individuals may communicate expressively using either augmentation to speech or alternatives to speech using various modalities such as paper and computer based communication displays (e.g., iPad), sign language, gestures, vocalizations, and speech. The overall AAC language acquisition literature emphasizes the role of language input for individuals with CCN who require AAC (Beukelman & Mirenda, 2013). Research in sign language acquisition, for example, stresses the importance of language input in the process of successful language development of children using sign language, demonstrating that given sign language input, children can develop complex language abilities (Bavelier, Newport & Supalla, 2003; Newport & Supalla, 2000).

Additionally, individuals with CCN who use aided AAC systems, such as those with paper or computer based picture or word systems, require appropriate language input (Romski & Sevcik, 1996). However, these individuals rarely observe models of AAC use, creating what
Smith & Grove (2003) called an asynchrony of language input to output. That is, these individuals experience spoken language as input, but are expected to communicate using AAC. Consequently, a number of AAC interventions, have been developed in an attempt to provide this missing language input to individuals with CCN as a way to stimulate language gains (see single-subject meta-analysis; Sennott, Light, & McNaughton, 2012). For clarity and conciseness, Sennott, Light, and McNaughton (2012) used the term AAC modeling to consolidate and describe the various types of language input provided through AAC modalities.

AAC modeling intervention packages positively impact four different language areas: (a) pragmatics in the form of turn taking; (b) semantics in the form of receptive and expressive vocabulary; (c) syntax in the form of increasing multi-symbol utterances; and (d) morphology in the form of increased use of target structures. Meta-analysis results also indicated that because of the packaged nature of the interventions, parsing out modeling as the sole independent variable impacting student performance was difficult. What was found, in addition to the modeling variable, time delay or expectant delay, and responding or recasting, were included in the majority of the reviewed packaged interventions. Those three intervention variables are included in a newly designed intervention package called ModelER (Model, Encourage, Respond) + Read and Talk.

**ModelER for Read and Talk**

The ModelER for Read and Talk intervention package is built on theory supporting the importance of language input (Gallway & Richards, 1994; Hart & Risley, 1995, Tomasello, 2003) and effective instructional components as highlighted in the single subject meta-analysis (Sennott, Light, & McNaughton, 2012). ModelER is designed to provide an optimized language-learning environment for beginning communicators with CCN who require AAC and who have been observed to take a low number of communication turns in school settings. ModelER has been designed to create the circumstances Fey (1986) described, namely that providing increased
opportunities for communication establishes a forum where a range of communication goals can be targeted and practiced. Specifically, ModelER for Read and Talk is formulated to capitalize on the language rich context of shared storybook reading by creating a forum of rich communication interactions that include AAC modeling.

**ModelER.** The Improving Partner AAC Training (ImpAACt) series of studies (Binger et al., 2008; Binger et al., 2010; Kent-Walsh, Binger, & Hasham, 2010; Rosa-Lugo & Kent-Walsh, 2008) effectively used variants of a shared reading specific strategy instructional package (Read, Ask, and Answer: RAA) to teach partners to better engage in shared storybook reading with beginning communicators who use AAC, demonstrating strong positive results (Sennott, Light, & McNaughton, 2012). In contrast, ModelER has been designed for generalization beyond the initial reading context, because of the importance of promoting interventions that can be used across multiple contexts, which is essential for children learning to use AAC.

The major components of ModelER are (a) model - modeling AAC use (Sennott et al., 2012); (b) encourage - encouraging communication through time delay/expectant delay (e.g. Halle, Baer, & Spradlin, 1981); and (c) respond - responding to child communication attempts through recasting (Camarata & Nelson, 2006; Nelson et al., 1996; Harwood, Warren, & Yoder, 2003). AAC modeling is the foundation of the intervention and is designed to provide a model of language use (pragmatics), content (semantics), and form (syntax) for the individual with CCN learning to use AAC. Encouragement to communicate, in the form of a time delay, is designed to provide opportunities for the child to initiate a communication turn, showing them that the adult communication partner is waiting and interested. As a support to the child’s communication attempts, the respond component focuses on recasting the child’s utterance by repeating their utterance, and expanding it in a meaningful way when possible. This is designed as an adaptation of the intervention described in Nelson et al. (1996) in that the recast maintains the basic meaning of what they child says and focuses on expanding the length of utterance while keeping the
conversation turns flowing. The hope is that the child can better attend to the more advanced structures being modeled, if it is based on something they just communicated. Put together, modeling, encouraging by waiting for the child to take a turn, and then responding through recasting is designed to create individualized, language rich multi-turn communication sequences.

**Read and Talk.** The Read and Talk component of the package refers to reading a book and talking about it through making comments or asking questions. The Read and Talk components create a learning environment that would be typical of an early childhood shared reading context. Variants of shared storybook reading, such as dialogic reading, that includes engaging in conversation with the child, has extensive empirical support in general education (Dale et al., 1996; Whitehurst et al., 1988), special education (Ezell & Justice, 2005), and AAC specific literatures (Bedroisian, 1999; Sennott, Light, & McNaughton, 2012; Stephenson, 2009).

The approach taken in the Read and Talk components of the intervention expands on the ImpAACt studies by including commenting in addition to question asking. Reading and asking children questions is frequently the basis of dialogic reading interventions (e.g. Dale et al., 1996), yet this has the potential to place the child into a passive or question prompt dependent role, one that can be detrimental to individuals who require AAC (Light & Kelford Smith, 1994). Instead, this preliminary study is designed to teach the communication partners to model multiple pragmatic functions, comments and questions, with the objective of promoting the children taking increasingly independent turns, such as making comments or asking questions themselves.

**Research Questions**

This study evaluates the effects of the ModelER for Read and Talk package on EA instructional practice and child communication performance, in an early childhood educational setting, in the context of shared storybook reading. The following questions are addressed:

1. What is the impact of the ModelER for Read and Talk instruction on EA performance of AAC modeling, the encourage step, and the respond step?
2. What is the impact of the EA's implementation of ModelER for Read and Talk on the child’s communication performance measured by frequency of iPad AAC turns, gesture turns, and speech turns, and total communication turns?

Method

The setting for the present study was a public early childhood center in a university town housing six different early childhood classrooms for approximately 75 children with and without disabilities. The study’s two participants were members of two different classrooms that were specially designed to serve children with autism spectrum disorders and included features such as a low teacher to child ratio (one adult to two children), a highly structured sequence of activities, and instruction focused on the children’s individualized education plan (IEP).

Participants

Following university IRB approval of the study, local preschools were contacted and potential students were nominated to be included in the study. Students and EAs were considered based on specific inclusion criteria. The inclusion criteria for selecting children to participate in the study was an adaptation of recommendations described in Bedrosian (1999) and in the ImpAACt studies (Kent-Walsh, Binger and colleagues) for shared storybook reading interventions and included the following qualifications: (a) children aged 3 to 5 years; (b) had severe speech impairment as evidenced by no intelligible speech production or a repertoire of fewer than 50 intelligible spoken words; (c) currently using an aided AAC system (e.g. communication board, speech generating device); (d) language comprehension no lower than a two year developmental level; (e) language production involving one- to three-symbol productions; and (f) functional hearing and vision assessed as being within normal limits, with aids. The inclusion criteria for the EA that worked with the child included the following qualifications: (a) the individual works with the child regularly (typically at least 3x per week)
and (b) has worked with the child for longer than 4 weeks. Parental consent, EA consent, and child assent was acquired prior to commencement of the study.

In order to describe participant language skills, school report and observation was used to provide a description of their expressive language level and participants were each given the TACL-3 to provide a measure of their receptive language level (See table 1).

Table 1. Participants

<table>
<thead>
<tr>
<th>Participant, gender, age</th>
<th>Disability</th>
<th>EA, age, experience in schools</th>
<th>TACL-3 Score</th>
<th>AAC System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bobby, Male, 3;1</td>
<td>Developmental delay, in process of autism assessment</td>
<td>Beth, 40, 4 years</td>
<td>2;7</td>
<td>16%</td>
</tr>
<tr>
<td>Amanda, Female, 5;2</td>
<td>Developmental delay, in process of autism assessment</td>
<td>Alexandria, 47, 12 years</td>
<td>3;6</td>
<td>1%</td>
</tr>
</tbody>
</table>

Note. EA = Educational Assistant, TACL-3 = Test of Auditory Comprehension of Language, 3rd Edition (Carrow-Woolfolk, 1999) SS = standard score

Bobby. Bobby is a three year, one month old boy who is diagnosed with a developmental delay and is suspected to have an autism spectrum disorder (ASD). At the time of the study, he participated in a specialized pre-school classroom designed for children with ASD that included a high level of support (one adult to two children) for children attending the classroom. Bobby was nominated for inclusion in the study because of the low number of intelligible communication turns he was taking during the day and because his team was trying to further incorporate AAC system components to aid in meeting his daily communication needs. At the start of the study, as reported by the school, Bobby successfully used some intelligible words (<10), vocalizations, some signs (<10), and gestures such as pointing to communicate. It was reported that he would frequently try to imitate adult speech, but often the result was unintelligible. As demonstrated by
his performance on the TACL-3, his receptive vocabulary scores were slightly below average for his age.

**Amanda.** Amanda is a five-year, two-month old girl who is also diagnosed with a developmental delay and is suspected of having an ASD. Similar to Bobby, but with a different teacher, she participated in a specialized pre-school classroom designed for children with autism spectrum disorders (ASD). Amanda had a one-to-one educational assistant assigned to work with her, who had worked with her for more than six months during the current school year. Amanda was nominated for participation in the study because of the low number of communication turns she was taking throughout the day. For a primary component of her communication system, she was using a 60-location core vocabulary based AAC display adapted onto an iPad with Proloquo2Go. She had most of the vocabulary items on the display masked, hiding all but 10 to 15 symbols for most activities. Additionally, as reported by the school, she frequently used a range of gestures, such as pointing and shoulder shrugs, less than five signs, and very infrequently used vocalizations to communicate. As evidenced by her performance on the TACL-3, her receptive vocabulary scores were well below average for her age.

**Procedures**

A multiple-case study design was used (Yin, 2009) with the unit of analysis being the child and EA dyad’s individual performance during shared storybook reading in response to introduction of the ModelER for Read and Talk strategy instructional package. This case study design is ideal for a preliminary study in preparation for single-subject multiple baseline designs because it allows for rapid testing of the procedures and measures with multiple participants.

**Measures.** In addition to the measurement of the EA training by the researcher, there were two primary sets of measures, one targeting EA and one targeting student behaviors. Teacher targeted behavior measurements focused on the levels of intervention variables performed by the EAs during the shared storybook reading sessions (see Table 2 for definitions).
Table 2. ModelER for Read and Talk strategy components

<table>
<thead>
<tr>
<th>Strategy Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>EA models one or more AAC symbols during a communication turn using the iPad based AAC system.</td>
</tr>
<tr>
<td>Encourage</td>
<td>EA provides a time delay, or wait time, until child takes a communication turn or five seconds.</td>
</tr>
<tr>
<td>Respond</td>
<td>EA responds to a child communication turn by repeating some portion of the child’s utterance and attempts to expand the utterance and models one or more AAC symbols during a communication turn using the iPad based AAC system.</td>
</tr>
<tr>
<td>Read</td>
<td>EA reads a page or page spread in the book and uses ModelER.</td>
</tr>
<tr>
<td>Talk</td>
<td>EA makes a comment or asks a question using ModelER.</td>
</tr>
</tbody>
</table>

Using video analysis of the sessions, the following components were measured: (a) AAC modeling, (b) encouragement (time delay), and (c) responding (recasting). The AAC modeling component consisted of the teacher activating at least one AAC symbol on the iPad and speaking out loud either before, during or after the model, a modification of the approach described in Kent-Walsh, Binger, and Hasham (2010). AAC modeling turns by the EA were separated by either the child initiating a turn or five seconds without teacher activation of an AAC symbol on the iPad. Pointing to an item on the AAC system and activation of navigational items were not counted as AAC models. Measurement of the encouragement (time delay) component was adapted from Halle, Baer, and Spradlin (1981) and consisted of (a) the EA not vocalizing or using AAC until the child took a turn or for at least five seconds and (b) the EA looking in the direction of the child. The responding (recasting) component was adapted from Nelson and colleagues (1996) and consisted of the EA providing an AAC model that repeated some part of what the child had just previously communicated and then provided some sort of expansion to the child’s utterance.
Student target behavior measurements, in the form of student communication turns, were collected to measure student performance (Carter, 2003). Using video analysis, each student communication turn was coded for total number of communication turns (see Table 3). The definition of a communication turn was adapted from Carter (2003) and included the student engaging in a communicative act through one or more of the following communication modalities: (a) AAC device use; (b) gesture or sign language use; and (c) speech or vocalization. The communication turns had to include evidence of intentionality, so for instance an accidental iPad press with the elbow was not counted as AAC device use. The boundary of the communication turns were either (a) the teacher initiating a turn or (b) a five second duration.

Table 3. Child communication turn descriptions

<table>
<thead>
<tr>
<th>Turn Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total communication turns</td>
<td>Communication turns are defined as use of the AAC system, vocalization or speech, or a gesture (ex. pointing). A turn is considered finished by the communication partner taking a turn or a pause of more than five seconds and a change of communication focus. Communication turns can include more than one modality (e.g. a turn with a gesture and an AAC system activation). Only communication turns related to the shared storybook reading were coded (e.g. Not turns such as pointing to a new ear ring).</td>
</tr>
<tr>
<td>AAC</td>
<td>Child uses the AAC system by activating a vocabulary item. Navigational items were not coded as an iPad AAC turn.</td>
</tr>
<tr>
<td>Gesture</td>
<td>Child uses a gesture or sign (e.g. pointing at a picture in the book).</td>
</tr>
<tr>
<td>Speech</td>
<td>Child makes a communicative vocalization or speaks words.</td>
</tr>
</tbody>
</table>

**Baseline.** A minimum of five baseline sessions were conducted for each participant, resulting in five sessions for Bobby, and seven sessions for Amanda. The baseline conditions for the shared storybook reading sessions included three paper storybooks from the Biscuit series of books by Alyssa Satin Capucili, an iPad with AAC software, and a table and chairs. The EAs were instructed to engage in the shared storybook reading session as they normally would with the child. The iPads included the AAC software Proloquo2Go (Sennott & Bowker, 2009) with
vocabulary displays for each book that included both shared core vocabulary and book specific words. See Figure 1 for an example iPad AAC vocabulary display.

![Figure 1. iPad AAC vocabulary display for Biscuit Goes to School](image)

**Intervention.** The intervention consisted of a 90-min EA training that was conducted in one session. Following this training, EAs resumed shared storybook reading sessions with the child, practicing implementing ModelER for Read and Talk using the same books and iPad AAC displays. The principal investigator was present during sessions, serving as a coach. After reaching five intervention sessions and when a minimum 50% mean difference increase in communication turns was achieved, or after 10 intervention sessions, post-intervention sessions were conducted where the EA worked independently, receiving no coaching.

Training EAs for ModelER for Read and Talk was primarily based upon the six components of explicit instruction for strategy acquisition (Harris, Graham, & Mason, 2003) and
included the following steps: (1) develop background knowledge; (2) discuss ModelER for Read and Talk; (3) model ModelER for Read and Talk; (4) memorize ModelER for Read and Talk; (5) support ModelER for Read and Talk; and (6) independent performance ModelER for Read and Talk. Following at least five stable student baseline points for communication turns, EA training steps one through five were implemented in an approximately 90-min live training with the principal investigator. The storybook reading sessions that followed this training were considered intervention sessions and included the same materials and conditions during baseline. Additionally, during intervention sessions, the principal investigator continued step five of the training model by assuming the role of tutor by providing coaching and informative feedback during the session. The tutor sat at the same table as the child and EA during the intervention sessions and provided feedback in the form of praise, corrective feedback, and prompting.

Post-Intervention. Post-intervention sessions were to be conducted after five intervention sessions and when a minimum 50% increase in communication turns was achieved, or after 10 intervention sessions. Post-intervention represents step number six in the training model, or independent performance of ModelER for Read and Talk. All conditions were the same as during baseline and intervention, with the exception of the tutor’s presence, which was removed during post-instruction.

Scoring. In order to code for the study measures, each shared storybook reading session was video taped with the camera positioned so that the faces of the EA and student and use of the AAC communication system could be seen. Researcher led training sessions were also video taped and then later scored for correct implementation. Scorers used the session videos and the video analysis software StudioCode to code the videos for target behaviors for the EAs and the students. The scorers were graduate students in special education who had taken coursework in research methods and had completed study specific training which involved watching sample
videos and practicing coding using the coding guides to develop competency with coding the study variables.

**Inter-observer Agreement.** Inter-observer agreement was measured for the researcher implementation of the six-part training model, teacher target behaviors, and student target behaviors. For researcher implementation, two graduate student scorers observed the training videos for both Bobby and Amanda’s EAs and found 100% implementation for steps one through six for Amanda’s EA, and found 100% implementation for steps one through five for Bobby’s EA, as Bobby did not complete post-intervention sessions.

For each participant, for both teacher and student variables, at least 20% of the sessions across each of baseline, intervention, and post-intervention were scored by a second rater and total agreements were calculated and all variables were found to be within acceptable limits (Kazdin, 2011). For the combined number of AAC models performed by the EAs agreement averaged 97% (range= 88% to 100%). For EA model steps, agreement averaged 89% (range= 67% to 100%). EA encourage step agreement averaged 91%, (range= 78% to 100%). For EA respond steps, agreement averaged 90%, (range= 67% to 100%). Total communication turn agreement averaged 97% (range = 85% to 100%). For iPad AAC turns, agreement averaged 93% (range 82% to 100%). Gesture turn agreement averaged 83% (range= 50% to 100%). Speech turn agreement averaged 82% (range 0% to 100%).

**Analysis.** To analyze the participant performance, the single subject research analysis procedures used were: (a) visual analysis of level and trend (Kazdin, 2011); (b) descriptive statistics in the form of mean differences (calculated as the mean of intervention minus the mean of baseline); and (c) percentage of non-overlapping data (PND) (Scruggs, Mastropieri, & Casto, 1987) (calculated as the ratio of the number of intervention data points above the highest baseline point) (Parker, Vannest, & Davis, 2011).
Results

The results are described by student, in the following order: (1) EA instructional variables will be reported; (2) the number of AAC models and encourage steps (wait time) performed by the EA will be described; (3) student communication performance will be reported; and (4) the number of communication turns and types of turns, such as AAC, gesture, or speech turn will be described.

Bobby

EA Variables. From baseline to intervention, Bobby’s EA made very large gains in level for the number of overall AAC models performed and experienced an upward trend over the five intervention sessions (See Figure 2). At baseline, Bobby’s EA was performing a very low number of AAC models, a mean of .5 AAC models, ranging from a low of 0 AAC models over four sessions to a high of one and three models in the two other baseline sessions. During intervention, Bobby’s EA increased in level; the total number of AAC models to a mean of 26.6, with 100% non-overlapping data. The majority of the gain in AAC models was represented in the respond step of the strategy, with the AAC models increasing from a mean of .3 at baseline to a mean of 19.8 during intervention, with 100% non-overlapping data. A more modest gain was represented in the model step with AAC models increasing from a mean of .17 at baseline, to a mean of 6.8 during intervention, with 100% non-overlapping data. Overall, the level and trend in AAC models performed by Bobby’s EA were large and immediate.
Figure 2. The combined number of AAC models performed by the EA during shared storybook reading sessions with Bobby, including models from both the model and respond steps.

Similarly, Bobby’s EA also experienced a substantial level increase in the number of encourage steps performed and the trend increased steeply (See Figure 3). At baseline she was performing a mean of 6 encourage steps with a range from a low of 2 to a high of 9. During intervention, the mean encourage steps increased to 18.8, with a high of 36 encourage steps in the final intervention session, with 80% non-overlapping data.
Student Variables. Bobby increased in level the total number of communication turns taken from baseline to intervention with an upward trend demonstrated only over the last two data points (See Figure 4). During baseline he took a mean of 24.3 turns, ranging from a low of 17 turns to a high of 32 turns and the majority of these turns were gestures, as evidenced by the mean of 16.8 gestures during baseline. Moreover, nearly all of these gestures were in the form of pointing at pictures in the book. A smaller number of the turns in baseline were iPad AAC turns (mean= 4.7), and speech turns (mean = 6.7).
Figure 4. The number of communication turns taken by Bobby during shared storybook reading sessions and modalities used during communication turns.

During intervention, the total number of communication turns increased to a mean of 46 turns, a mean difference of 21.7 turns, or an 89% gain, with 100% non-overlapping data from baseline. The increase in turns was represented in the AAC and speech modalities and a decrease in turns was represented in the gesture modality. Bobby’s AAC turns demonstrated a very large level change with an upward trend in the data. His AAC turns increased to a mean of 34.6 AAC turns, a mean difference of 29.9 turns, or a 641% gain, with 100% non-overlapping data. (See Table 4) His speech turns also demonstrated a very large level change with a steep upward trend. His speech turns increased to a mean of 26.8 turns, a mean difference of 20.1 turns, or a 302%
gain, with 100% non-overlapping data. Bobby’s gesture turns made a modest decrease in level with a stable trend, shifting from 16.8 turns at baseline, to 5.8 turns during intervention, representing a mean difference of 11 turns, or a 65.5% decrease (See Figure 4). These gains represent a clear shift from the predominance of gesture turns during baseline to the majority of the turns in the course of intervention being AAC and speech turns.

Table 4. *Student communication turns descriptive statistics and PND*

<table>
<thead>
<tr>
<th>Participant</th>
<th>Turn Type</th>
<th>Base</th>
<th>Int</th>
<th>Post-Int</th>
<th>Int Total</th>
<th>MD Int Total</th>
<th>MD %</th>
<th>PND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bobby</td>
<td>Combined</td>
<td>24.3</td>
<td>46</td>
<td>NA</td>
<td>46</td>
<td>21.7</td>
<td>89%</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>AAC</td>
<td>4.7</td>
<td>34.6</td>
<td>NA</td>
<td>34.6</td>
<td>29.9</td>
<td>641%</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Gesture</td>
<td>16.8</td>
<td>5.8</td>
<td>NA</td>
<td>5.8</td>
<td>-11</td>
<td>-66%</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Speech</td>
<td>6.7</td>
<td>26.8</td>
<td>NA</td>
<td>26.8</td>
<td>20.1</td>
<td>302%</td>
<td>100</td>
</tr>
<tr>
<td>Amanda</td>
<td>Combined</td>
<td>37.4</td>
<td>41.2</td>
<td>51</td>
<td>42.8</td>
<td>5.4</td>
<td>14%</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>AAC</td>
<td>29.3</td>
<td>36.7</td>
<td>43.5</td>
<td>37.8</td>
<td>14.2</td>
<td>29%</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Gesture</td>
<td>23.7</td>
<td>16.8</td>
<td>29</td>
<td>18.8</td>
<td>-4.9</td>
<td>-21%</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Speech</td>
<td>0.71</td>
<td>0.8</td>
<td>1.5</td>
<td>0.91</td>
<td>0.2</td>
<td>28%</td>
<td>0</td>
</tr>
</tbody>
</table>

*Note.* Base= Baseline, Int= Intervention, MD= Mean difference, PND = Percentage of non-overlapping data, Post-Int = Post intervention
**Amanda**

**EA Variables.** At baseline, Amanda’s EA was already performing components of the ModelER and Read and Talk strategy (See figures 5 and 6). Over the seven baseline reading sessions, she provided a high of 20 AAC models and a low of 10 AAC models. The majority of these AAC models came during the read and talk steps, compared to a smaller number coming during the respond step. Comparably at baseline, Amanda’s EA was completing a relatively high number of time delays, in essence the encourage step, ranging from a high of 27 to a low of 10.

![Graph showing the number of AAC models over sessions](image)

*Figure 5.* The combined number of AAC models performed by the EA during shared storybook reading sessions with Amanda, including models from both the model and respond steps.
Figure 6. The number of encourage steps performed by the EA during shared storybook reading sessions with Amanda.

Following the relatively high baseline levels, during the intervention phases and post-intervention phases, Amanda’s EA made large level increases in the total number of AAC models and a small level increase in the number of encourage steps provided during book reading (See figure 4). There were relatively flat trends in the data for both AAC models and encourage steps.

At baseline, Amanda’s EA performed a mean of 15 total AAC models and then increased to a mean of 40.5 AAC models during intervention, with 100% non-overlapping data points. These gains were maintained during the two post-intervention sessions with total AAC models equaling 47 and 38 in those sessions, with 100% non-overlapping data points from baseline. In contrast to
baseline, the majority of the AAC models provided by the EA during intervention and post-intervention were performed during the respond step of the strategy. AAC models in the respond step increased from a mean of 2.3 during baseline to 27 during intervention and 31 post-intervention. The AAC models in the model step had very little variance, as they only increased from a mean of 12.7 at baseline to 13.5 AAC models during intervention and dipped to 11.5 during post-intervention. The improvement in the number of encourage steps was modest, with a change from a mean of 19.1 at baseline to 30.8 during intervention, with only 60% non-overlapping data points (See figure 6). Similarly, in the two post-intervention sessions, Amanda’s EA provided 31 and 26 encourage steps, which was only 50% non-overlapping data from baseline.

**Student Variables.** Overall, Amanda did not make a clear level or trend change in total communication turns from baseline to intervention and post-intervention (See figure 7). At baseline she was already taking a relatively high number of communication turns, with a mean of 37.4 turns (Range= 25 to 50). Her mean number of turns for intervention sessions was 41.2, and 42.8 for total sessions inclusive of post-intervention sessions, representing only a very modest 5.4 turn mean difference, or 14.4%, with only 25% non-overlapping data. (See Table 4) Although her post intervention performance did represent additional gains, with a mean number of turns equaling 51. This remains a modest mean difference of 13.6 turns, or 36.3%, with only 50% non-overlapping data from baseline.
Amanda did not make a clear level or trend change in communication turns using the AAC system as a communication modality. She increased from a baseline mean of 29.3 iPad AAC turns to a mean of 37.8 iPad AAC turns for total sessions, representing a modest mean difference of 8.6 iPad AAC turns, or 29%, with 33% non-overlapping data. Similarly to Amanda’s overall turn performance, she demonstrated larger gains in the post-intervention sessions, where she took 49 and 38 iPad AAC turns, equaling a 14.2 iPad AAC turn mean difference, or 48.5%, with 50% non-overlapping data from baseline.
Nonetheless, these are considered relatively modest gains considering they are after 10 intervention sessions.

**Gesture and Speech Turns.** Amanda’s gesture turns were also relatively high during baseline, at a mean of 23.7 (Range= 17 to 33). The number of gesture turns made a modest decrease in level with a stable trend during intervention, decreasing to 16.8, representing a modest 4.9 turn decrease, or 20.6%. Then, the number of gesture turns increased during post-intervention, to a mean of 29, representing a 5.3 turn mean difference, or 22%, with 0% non-overlapping data. Amanda’s speech turns were consistently low across baseline, intervention, and post-intervention. The number of speech turns ranged from a low of 0 recorded for ten sessions, to a high of 3 speech turns, recorded in two sessions one in each of baseline and post-intervention.

**Discussion**

The EAs who worked with Bobby and Amanda both made meaningful gains in the number of AAC models and encouragement steps in response to the strategy instruction, although at baseline they started at very different instructional levels. During baseline, Bobby’s EA was able to engage with him in shared storybook reading sessions, but demonstrated very low levels of the instructional strategy variables. Conversely, Amanda’s EA was demonstrating a relatively high degree of competency in providing AAC models and encouragement steps during baseline. In essence, Amanda’s EA demonstrated a degree of the ModelER for Read and Talk strategy present “in the wild” of a classroom setting prior to intervention. In addition, during the 90-min researcher led training session, Bobby’s EA remarked that she had not thought of using the AAC device as her own voice and expressed excitement about the new possibilities.

Interaction during intervention sessions was characterized by relatively large numbers of total AAC models and encourage steps by both participant’s EAs. Bobby’s EA made the largest gains in both AAC models and encourage steps. Representing the largest gain in AAC models,
Bobby’s EA shifted from a high of 2 AAC models performed during baseline to a mean of 26.6 AAC models (range=18 to 34) during intervention. This demonstrated a completely different instructional emphasis where the AAC system had become a frequent tool used both by the EA and the student. Additionally, Amanda’s EA, despite the high baseline levels of teacher instructional variables, still made relatively large increases in total AAC models performed and modest increases in the number of encouragement steps performed. For both participants EAs, most of the AAC models came during the respond step, meaning that they came after Bobby or Amanda had taken a communication turn, putting the AAC models in the context of a multi-turn conversational sequence. Taken together, Amanda and Bobby’s EA instructional performance gains provide evidence to suggest the strategy instruction was both effective at impacting a more novice and a more skilled EA’s behavior in a relatively short amount of time, a 90-min training plus 5 to 10 shared storybook reading sessions.

In addition to the instructional gains by the EAs, there are demonstrated communication gains represented by Bobby and to a lesser extent Amanda in the form of frequency of communication turns. Specifically, increased instructional performance by the Bobby’s EA corresponded with Bobby experiencing large increases in the total number of communication turns, and specifically in AAC and speech turns. Hitting a session high of 66 overall communication turns, with 51 iPad AAC turns and 35 speech turns represents the extent of these gains. In addition, the majority of his communication turns during baseline were gestures and primarily were instances of him pointing to pictures in the storybook. During intervention, they were replaced with AAC and speech turns, as he made a decreased number of these pointing gestures. These gains in AAC and speech turns represent a beneficial shift into communication modalities that can expand beyond the scope of present contexts and into flexible, generative language.
However, Amanda made only modest gains in the total number of communication turns taken during intervention sessions, despite her EA performing increased levels of the instructional variables. An important detail to consider for interpreting this result is that Amanda demonstrated an accelerating baseline for total communication turns, which resulted in an overall relatively high number of total communication turns at baseline.

Two factors seem to be contributing to the accelerating baseline and the resulting high baseline turn level. First, the shared storybook reading sessions were conducted using a repeated reading format. In the initial sessions, the EA read all three books to Amanda each session. It is believed that the increased familiarity with the specific texts could have contributed to her success across the seven-session baseline period. Second, her EA was already performing relatively high numbers of the intervention variables, which could have facilitated her growth during baseline to the resulting high level of communication turns.

In any case, even with Amanda’s EA performing increased levels of AAC modeling and encourage steps, Amanda only made modest gains in the total number of communication turns during the ten-min shared storybook reading sessions. iPad AAC turns increased the most, while similarly to Bobby, gesture turns decreased a small amount, and speech turns were flat across baseline and intervention. Three areas are important to consider when interpreting these results.

First, it is suspected that there is a ceiling level for frequency counts of communication turns. It is believed that Amanda may have been close to her ceiling level at baseline, which included experiencing the repeated readings plus the already present EA strategic instruction. If this were indeed accurate, frequency of total communication turns would not be an adequately sensitive dependent variable. Second, because Amanda’s EA did make substantial gains in the total number of AAC models provided, there may have been less of an opportunity for Amanda to take an increased number of communication turns. This is because the EA would have been taking more time to perform the increased number of AAC models, thereby leaving less time for
Amanda. Third, it was anecdotally observed by the EA, the researcher, and the two scorers that the quality of Amanda’s turns increased substantially during intervention and post-intervention.

**Future Research**

In summary, the EA’s clear gains and the varied gains by Bobby and Amanda provide preliminary evidence of the effectiveness of the ModelER for Read and Talk strategy instructional model. Yet, it is important to note that this preliminary evidence is at the case study level and therefore should be interpreted with the limitations inherent of that evidence level. This leads to the overall conclusion that the approach should be investigated further with future research including more participants and increasing levels of experimental control with all participants engaging in post-intervention sessions.

For future research and refinement of the instructional model, it is important to note both EAs demonstrated an increase in trend for their instructional performance over the sequence of the 5 intervention sessions for Bobby and 10 sessions for Amanda. This can be interpreted that practice had a positive effect on performance. For future research, additional focused practice during the training session should be assessed to determine impact on performance during initial intervention sessions. In addition, for future research, less invasive coaching methodologies could be explored such as bug-in-the-ear technology, in contrast to the present tutor at the table approach, to control for participant distraction.

Additionally, future research is needed to further evaluate if the strategy instruction can generalize to increase overall and AAC communication turns for other children like Bobby, who are taking a low number of communication turns that are primarily simple gestures, vocalizations, and one word speech utterances. For children like Amanda who are experiencing higher levels of the intervention variables at baseline, future research could explore the potential to break through ceiling levels and alternatively use more appropriate dependent variables, such turn quality.
variables in addition to the turn fluency variable. For children like Amanda, three communication turn quality variables of interest are turn initiation, multi-symbol utterances, and multi-turn sequences.

**Implications for Practice**

The preliminary evidence reporting increases in AAC modeling, recasts, and time delays by EAs in response to the ModelER for Read and Talk intervention package demonstrates that EAs can change their instructional performance efficiently when provided with training and tutoring. The increase in AAC modeling provides language input to children who require AAC to communicate, which matches the way they communicate expressively. The presence of these intervention variables, AAC modeling, recasts, and time delays, both “in the wild” during baseline and after training during intervention was correlated with the students taking relatively high numbers of communication turns during the shared storybook reading sessions. This positive student performance is consistent with comparable interventions that include AAC modeling and time delays (Sennott, Light, & McNaughton, 2012).
Appendix C

Internal Review Board approval letter

Date: March 06, 2012

From: The Office for Research Protections - FWA#: FWA00001534
       Joyel D. Moeller, Compliance Coordinator

To: Samuel C. Sennott

Re: Determination of Exemption

IRB Protocol ID: 38995

Follow-up Date: January 31, 2017

Title of Protocol: AAC Shared Storybook Reading Project

The Office for Research Protections (ORP) has received and reviewed the above referenced eSubmission application. It has been determined that your research is exempt from IRB initial and ongoing review, as currently described in the application. You may begin your research. The category within the federal regulations under which your research is exempt is:

45 CFR 46.101(b)(1) Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

Given that the IRB is not involved in the initial and ongoing review of this research, it is the investigator’s responsibility to review IRB Policy III “Exempt Review Process and Determination” which outlines:

6. What it means to be exempt and how determinations are made
7. What changes to the research protocol are and are not required to be reported to the ORP
8. Ongoing actions post-exemption determination including addressing problems and complaints, reporting closed research to the ORP and research audits
9. What occurs at the time of follow-up

Please do not hesitate to contact the Office for Research Protections (ORP) if you have any questions or concerns. Thank you for your continued efforts in protecting human participants in research.

This correspondence should be maintained with your research records.
Appendix D

Parent informed consent letter

Informed Consent Form for Social Science Research

The Pennsylvania State University

Title of Project: AAC Shared Storybook Reading Project

Principal Investigator: Samuel Sennott
Cedar Building
University Park, PA 16802
814-689-9849
samuel@psu.edu

Advisor: Dr. Linda Mason
Cedar Building
University Park, PA 16802
lhm12@psu.edu

1. Purpose of the Study: The purpose of this research study is to explore the effectiveness of training teaching assistants working with children who use augmentative and alternative communication (AAC) during shared storybook reading experiences.

2. Procedures to be followed: Your child will be asked to engage in shared storybook reading sessions with a teaching assistant they typically work with during school. The teaching assistant will be asked to engage in an informational session related to the project. The sessions will be video recorded and analyzed. Prior to these sessions, your child will engage in a preliminary screening evaluating speech intelligibility and language ability. At the end of the study the teaching assistant will complete a brief survey.

3. Duration/Time: The book reading sessions with the teaching assistant will take place at school and will last roughly 10 to 15 minutes. Prior to the first session, preliminary screening will take about 1 hour to complete. The total number of book reading sessions is expected to be between 15 and 20 sessions. Approximately two informational sessions for the teaching assistant will last approximately two hours. A brief survey will be completed by the teaching assistant at the end of the study, lasting approximately 10 minutes.

4. Statement of Confidentiality: Your participation in this research is confidential. The data will be stored and secured in a locked file. Data in digital form will be accessed only with a protected password by identified researchers. In the event of a publication or presentation resulting from the research, no personally identifiable information will be shared.

5. Right to Ask Questions: Please contact Samuel Sennott at 814-689-9849 with questions or concerns about this study.
6. **Voluntary Participation**: Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer.

7. **Audio/Visual Recordings**:

   ___ I agree that segments of the recordings made of my child's participation in this research may be used for conference presentations.

   ___ I do not want segments of the recordings made of my child's participation in this research to be used for conference presentations.

   ___ I agree that segments of the recordings made of my child's participation in this research may be used for education and training of future researchers/practitioners.

   ___ I do not want segments of the recordings made of my child's participation in this research to be used for education and training of future researchers/practitioners.

   If consent is not given to use the recordings for presentations or education and training, they will be destroyed three years from the start of the study.

   You must be 18 years of age or older to consent to take part in this research study. If you agree to take part in this research study and the information outlined above, please sign your name and indicate the date below.

   You will be given a copy of this form for your records.

   ____________________________________________  ____________
   | Participant Signature                           | Date               |
   |
   ________________________________  ____________________________
   | Person Obtaining Consent                       | Date               |
Appendix E

Educational assistant informed consent

Informed Consent Form for Social Science Research
The Pennsylvania State University

Title of Project: AAC Shared Storybook Reading Project

Principal Investigator: Samuel Sennott
Cedar Building
University Park, PA 16802
814-689-9849
samuel@psu.edu

Advisor: Dr. Linda Mason
Cedar Building
University Park, PA 16802
lhm12@psu.edu

1. Purpose of the Study: The purpose of this research study is to explore the effectiveness of training teaching assistants working with children who use augmentative and alternative communication (AAC) during shared storybook reading experiences.

2. Procedures to be followed: You will be asked to engage in shared storybook reading sessions with a student you typically work with during school. You will be asked to engage in an informational session related to the project. You will be asked to engage in a short survey about your experience participating in the project.

3. Duration/Time: The book reading sessions will last roughly 10 to 15 minutes. The total number of book reading sessions is expected to be between 15 and 20 sessions. The informational session will last approximately two hours. The survey will last approximately 10 minutes.

4. Statement of Confidentiality: Your participation in this research is confidential. The data will be stored and secured in a locked file. Data in digital form will be accessed only with a protected password by identified researchers. In the event of a publication or presentation resulting from the research, no personally identifiable information will be shared.

5. Right to Ask Questions: Please contact Samuel Sennott at 814-689-9849 with questions or concerns about this study.

6. Voluntary Participation: Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer.

7. Payment for participation: A choice of an Amazon or iTunes gift card of $50 will be
provided.

8. Audio/Visual Recordings:

____ I agree that segments of the recordings made of my participation in this research may be used for conference presentations.

____ I do not want segments of the recordings made of my participation in this research to be used for conference presentations.

____ I agree that segments of the recordings made of my participation in this research may be used for education and training of future researchers/practitioners.

____ I do not want segments of the recordings made of my participation in this research to be used for education and training of future researchers/practitioners.

If consent is not given to use the recordings for presentations or education and training, they will be destroyed three years from the start of the study.

You must be 18 years of age or older to consent to take part in this research study. If you agree to take part in this research study and the information outlined above, please sign your name and indicate the date below.

You will be given a copy of this form for your records.

_____________________________________________  ________________
Participant Signature                              Date

_____________________________________________  ________________
Person Obtaining Consent                           Date
Appendix F

Child assent

Assent Procedures for Social Science Research
The Pennsylvania State University
The researchers will complete the appropriate procedures as described below to obtain assent from the participating child. The appropriate procedures will be followed based on the child’s age.

Age 3-7
Introduce self and activity:
Researcher: Hello, my name is _______. I have some fun books for you to read with your teaching assistant. Will you please read with them?

Documentation of child’s assent will be recorded on the assent form (see below).

Age 8-13
Introduce self and activity:
Researcher: Hello, my name is _______ and I am a (Professor/Graduate student) at Penn State. I am interested in teaching reading to students. I have some really fun books for you to read with your teaching assistant. Reading these books helps students learn. Would you please read with them?

Documentation of child’s verbal assent will be recorded on the assent form (see below).
Title of Project: AAC Shared Storybook Reading Project

Principal Investigators: Samuel Sennott
University Park, PA 16802
814-689-9849; samuel@psu.edu

Other Investigators: Dr. Linda Mason
University Park, PA 16802

Purpose of the Study: The purpose of this research study is to explore training teaching assistants working with children who use augmentative and alternative communication (AAC) during shared storybook reading experiences.

Procedures to be Followed: You will be asked to participate in literacy activities. These activities are fun activities that help children learn.

Duration: Each session will last approximately 10 minutes, 4-5 days per week.

Voluntary Participation: It is your choice if you would like to read with your teaching assistant. Would you like to read with them?

Participant Response

________________________________________
Person Obtaining Assent

________________________________________
Date
Appendix G

Example book cover

Little Chimp by Jenny Giles; Illustrations by Rachel Tonkin
Appendix H

iPad in stand with books
Appendix I

Example AAC vocabulary displays

Little Chimp AAC Vocabulary Display

My School Bus AAC Vocabulary Display
Appendix J

Example symbols

Symbol Stix symbol examples

Minspeak Symbol examples
Appendix K

Ava’s setup

Keyguard by Lasered Pics
Appendix L

Guided Access setup directions

1. Under Settings, choose General, Accessibility

2. Under Accessibility, choose Guided Access
3. Under Guided Access, toggle to On.

4. Inside the app, triple click the home button and choose Guided Access

5. Circle areas on the screen to be disabled. Choose start to enable guided access.
Appendix M

Launcher screen
Appendix N

Child and educational assistant reminder cards

Child reminder card

Educational assistant reminder card
Appendix O

Selected iBook based training components

iBook Cover

iBooks bookshelf interface item
Table of Contents items:

Chapter 1 Background Knowledge and Discussion
1.1 ModelIR 2
1.2 Read and Talk 13
1.3 Together 19

Chapter 2 Demonstrations

Chapter 3 Practice
3.1 Memory 29
3.2 Practice: Live-Ituation 35
3.3 Practice 39
3.4 Practice: Situations 49
How might we learn about the meaning of Model, Encourage, Respond?

Tap on these to explore

Interactive 1.1 Model Analogy

How might we think about modeling AAC?

Model

Interactive 1.2 Encourage Analogy

How might we think about encouraging communication?

Encourage

Interactive 1.3 Respond Analogy

How might we think about responding to child communication?

Respond

Analogy stories

See how ModelER for Read and Talk fit together

Read

Child Communication

Encourage

Model

Talk

Child Communication

Encourage

Model

Explore the timeline

Interactive timeline
Why model?

How many words do children hear as they are learning a language?

Children experience millions of words spoken over the first years of their lives. Hart and Risley (1995) researched the question and discovered that in their first four years children hear from approximately 8 million to 50 million words. From this evidence, we know that children experience a lot of models.

In the gallery below, look at just a few of the situations where a young child begins hearing models, even before they are speaking.

**Interactive graphic**

**Interactive chart and photo viewer**

**One more thing..**

**Interactive graphic**
**Section 1**

**ModelER**

**Model**
- Model using AAC

**Encourage**
- Encourage by providing wait time (5 Seconds)

**Respond**
- Respond by repeating some part of what the child said and expand it modeling AAC

**KEY POINTS**
1. What is ModelER?
2. How does ModelER work in time?
3. What have others said about ModelER?
4. Why Model, Encourage, Respond?

ModelER stands for Model, Encourage, Respond. These three practices are designed to help children better communicate.

**Why Read and Talk?**

Variants of shared storybook reading, such as dialogic reading, that includes engaging in conversation with the child, has extensive empirical support in general education (Dale et al., 1996; Whitehurst et al., 1988).

There is also evidence to support this in the special education (Ezell & Justice, 2005), and AAC specific literatures (Bedroisian, 1999; Sennott, Light, & McNaughton, 2012; Stephenson, 2009).

Movie 1.1 Importance of talking about books
- Grover J. Whitehurst, Ph.D. discusses the importance of talking about books.

Movie 1.2 Dialogic Reading
- Grover J. Whitehurst, Ph.D. discusses dialogic reading with preschool-aged children.

**Embedded movies for background knowledge building**
Movie 2.2 Talk and Model, Encourage, Respond

ModelER annotated demonstration movies

Simulation prompt
Multiple choice quiz item

Drag and drop quiz item
Interactive flash cards
Appendix P

Bug-in-the-ear tutoring system diagram

1. EA hears feedback through the Bluetooth headset
2. The audio setup includes the session laptop running Skype configured with the audio in coming from the laptop open air microphone and the audio out going to the EA’s Bluetooth headset
3. The two laptops are connected via Wi-Fi to a local area network (LAN) providing a near real time connection
4. The tutor sees video and hears audio from the session via Skype and provides feedback in near real time over LAN.
# Appendix Q

## Educational assistant treatment acceptability survey results

<table>
<thead>
<tr>
<th>Prompt</th>
<th>Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rank the importance of each part of ModelER</td>
<td>1: Respond</td>
</tr>
<tr>
<td></td>
<td>2: Encourage</td>
</tr>
<tr>
<td></td>
<td>3: Model</td>
</tr>
<tr>
<td>1: Respond</td>
<td>1: Model</td>
</tr>
<tr>
<td>2: Encourage</td>
<td>2: Respond</td>
</tr>
<tr>
<td>3: Model</td>
<td>3: Encourage</td>
</tr>
<tr>
<td>Do you feel like ModelER for Read and Talk is something that fits easily into the child's classroom experience? Likert scale: 1 not easily, 5 easily</td>
<td>5</td>
</tr>
<tr>
<td>1: Model</td>
<td>2: Respond</td>
</tr>
<tr>
<td>2: Encourage</td>
<td>3: Encourage</td>
</tr>
<tr>
<td>3: Model</td>
<td>5</td>
</tr>
<tr>
<td>Did you feel better prepared to help the child you worked with learn to use AAC? Likert scale: 1 Not more prepared, 5 Much more prepared</td>
<td>5</td>
</tr>
<tr>
<td>1: Model</td>
<td>2: Respond</td>
</tr>
<tr>
<td>2: Encourage</td>
<td>3: Encourage</td>
</tr>
<tr>
<td>3: Model</td>
<td>5</td>
</tr>
<tr>
<td>Would you recommend the ModelER for Read and Talk program to others?</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Who would you recommend the ModelER for Read and Talk program to?</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>5</td>
<td>Other Educational Assistants</td>
</tr>
<tr>
<td>6</td>
<td>Parents</td>
</tr>
<tr>
<td>7</td>
<td>Teachers</td>
</tr>
<tr>
<td>8</td>
<td>Speech Therapists</td>
</tr>
<tr>
<td>9</td>
<td>Is there anything you would like to see changed?</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>10</td>
<td>Try to summarize the benefits of ModelER for Read and Talk in one sentence</td>
</tr>
<tr>
<td>11</td>
<td>Did participating in the study make you feel that the child should have an AAC system designed for them?</td>
</tr>
</tbody>
</table>
Appendix R

Custom data coding window
Appendix S

Transcription directions and style guide

1. Click on the code instance.

2. Click on the Text menu item.

3. Add the text using the style guide.

4. Close the text window by clicking the red dot in the left hand corner.

Style guide for transcription of child turn

<table>
<thead>
<tr>
<th>Type</th>
<th>Format</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAC</td>
<td>AAC(Kitty Cat).</td>
<td></td>
</tr>
<tr>
<td>Speech</td>
<td>Speech(Kitty Cat). Speech(Approximation(Kitty Cat)).</td>
<td></td>
</tr>
<tr>
<td>Vocalization</td>
<td>Vocalization(rrrrrrrrr that the helicopter makes).</td>
<td></td>
</tr>
<tr>
<td>Gesture</td>
<td>Gesture(Pointing to Kitty Cat). Gesture (Shrugging shoulders to ask why). Gesture (Shaking head for yes or no).</td>
<td></td>
</tr>
<tr>
<td>Sign</td>
<td>Sign(Kitty Cat) Sign(Fingerspell (Kitty Cat))</td>
<td>Note: Use sign dictionary when needed.</td>
</tr>
</tbody>
</table>
Samuel Sennott  
Department of Educational Psychology, Counseling, and Special Education  
The Pennsylvania State University  
University Park, PA 16802

Education
Anticipated Aug 2013  Ph.D., The Pennsylvania State University  
Major: Special Education  
Cognate: AAC  
Advisor: Linda Mason  
2007  M.S. Ed., Simmons College  
Assistive Special Education Technology

2004  B.S. Ed., Gordon College  
Majors: Special Education, Elementary Education, History

Professional Experiences
2009-present  The Pennsylvania State University, Graduate Research Assistant
2008-2010  Sennott Consulting, Co-creator of the Original Proloquo2Go
2007-2008  Nova Southeastern University, Lead Teacher, TLC Program in the  
Speech-Language and Communication Disorders Program
2006-2007  Triton Regional School District, MA, Co-director of Adventures in  
Learning and Fun Extended School Year Program
2006-2007  Triton Regional School District, MA, Assistive Technology Team  
Leader
2004-2007  Triton Regional School District, MA, Lead Teacher and Program  
Designer, Discovery Center Inclusion Program
1997-2005  The Michael Carter Lisnow Respite Center, Hopkinton, MA,  
Respite Worker

Awards/ Recognitions
2011  Autism Cares Award for Innovative Technology
2008-present  OSEP Preparing Outstanding Scholars for Special Education (POSSE)  
Scholarship Recipient at The Pennsylvania State University
2007  Suzanne Rich Memorial Award for an outstanding assistive technology graduate  
student at Simmons College, 2007

Select Publications
Augmentative and Alternative Communication, 18(4), 137-145.
Assistiveware.
AAC modeling on the communication and language development of individuals with  
complex communication needs.
Sennott, S., Mason, L., (In preparation). AAC modeling during shared storybook reading: A  
preliminary study of the effects of the ModelER for Read and Talk intervention package  
on communication performance in early childhood.