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The Effectiveness Of Errorless Learning For Teaching Concepts And Comments To Children With Autism

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THE EFFECTIVENESS OF ERRORLESS LEARNING FOR TEACHING

CONCEPTS AND COMMENTS TO CHILDREN WITH AUTISM

(TITLE)

BY

MARISSA L. ULM, B.S.

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Abstract

Research has indicated that errorless learning has been an effective teaching strategy for teaching discrete skills to both typically developing children and children with a learning disability (Schimek, 1983; Storm & Robinson, 1973). Errorless learning differs from other common teaching strategies in that it only presents correct responses, eliminating the possibility of participants responding incorrectly. The purpose of this study was to examine the effectiveness of errorless learning for improving symbol acquisition in children with autism who used a high-tech augmentative and alternative communication (AAC) device. Four children previously diagnosed with autism participated in this study; subjects were required to be established wants/needs level communicators on their AAC systems. This study employed a single-subject, ABABA withdrawal design and used a graded-choice errorless learning strategy for teaching new symbols to subjects. The researcher collected data on three variables: 1) symbol acquisition, 2) generalization, and 3) the level of assistance and cuing. Results of the study showed no clear pattern of symbol acquisition for any subjects; however, Subjects 3 and 4 moved along the graded-choice continuum for two symbols during errorless learning teaching sessions, indicating a level of mastery for these symbols. No clear pattern of generalization was exhibited for any subjects. However, all subjects showed a decrease in the level of assistance and cuing required during errorless learning teaching sessions. While no significant results were achieved, the limited results of this study lend support to the effectiveness of errorless learning for teaching children with autism.

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Chapter I

Introduction

Research has shown that children with developmental disorders often have accompanying significant communication impairments (American Speech-Language-Hearing Association [ASHA], 2005a; Batshaw, Pellegrino, & Roizen, 2007; Beukelman & Mirenda, 2005; Richard, 1997; Seif Workinger, 2005; Velleman, 2003). Research has also indicated that augmentative and alternative communication (AAC) systems are effective for increasing communication skills for these children (Beukelman & Mirenda, 2005; Glennen & DeCoste, 1997; Light & Binger, 1998). Although there is research supporting the use of AAC systems with children diagnosed with a developmental disability, the research is still relatively limited regarding which strategies are most efficient and effective for teaching language skills to these children.

Several strategies have been used previously and can be grouped into three main categories: symbol/display modifications (including color coding), naturalistic, and behavioralistic teaching strategies. Color coding is an effective display modification and organizational teaching strategy for improving symbol knowledge and operational competency in individuals who use an AAC system (Wilkinson, Carlin, & Jagaroo, 2006; Wilkinson, Carlin, & Thistle, 2008). However, color coding is typically used in conjunction with a naturalistic or behavioralistic strategy. Naturalistic teaching strategies such as milieu teaching, incidental teaching and aided language modeling have been shown to be effective for improving symbol acquisition for tasks such as for requesting, making choices and combining symbols in children with developmental disabilities. Behavioralistic strategies have also been found to be effective in increasing communication behaviors. Discrete trial training (DTT) is one such strategy that has been examined for increasing vocabulary/symbol knowledge in children who use AAC systems (Downs, Downs, Johansen, & Fossum, 2007; Smith, 2001). DTT is an adapted applied behavior analytic teaching strategy consisting of five main parts (cue, prompt, response, consequence, intertrial interval). DTT focuses on strictly controlling the teaching situation and is, therefore, closely related to an errorless learning procedure.

Errorless learning has been a part of the research literature in other fields for several decades but has not been studied in the field of AAC until recently. Errorless learning is a strategy which allows the researcher or clinician to control the stimulus presented, as well as the response, in order to reduce incorrect responding until an individual has gained mastery over a task. This strategy is a form of operant conditioning and, as such, has been studied largely from a behavioral perspective. It has been shown to be effective for teaching visual and auditory discrimination tasks to typically developing children and children with learning disabilities (Schimek, 1983; Storm & Robinson, 1973). Recently, errorless learning was examined and found to be an effective teaching strategy for typically developing children for improving operational skills to successfully use an AAC system (Quach & Beukelman, 2010). Although this research study was limited to a small number of typically developing children, it did suggest that errorless learning may be an effective teaching strategy for AAC users. As previously stated, DTT and errorless learning are closely related teaching strategies sharing the same theoretical construct. This fact, in conjunction with the research in the field of speech-language pathology supporting behavioral teaching strategies such as DTT for improving language skills in individuals with developmental disabilities, indicates that errorless learning may be a successful strategy for teaching new language skills to children with developmental disabilities who use an AAC system for communication. Mueller, Palkovic, & Maynard (2007) hypothesized that errorless learning would be beneficial for children with developmental disabilities, especially those with pervasive developmental disorders (PDD) because it limits frustrations and allows the children to establish a routine around the correct response instead of attempting to change a routine established around an incorrect response as can occur with other typical teaching strategies. Overall, more research is needed to examine the efficacy of errorless learning as a teaching strategy for individuals with a developmental disability who use AAC systems as a primary mode of communication.

Chapter II

Review of the Literature

Overview

This chapter begins with a brief discussion of developmental disabilities and how these disabilities can impact a child's speech and language. A discussion of augmentative and alternative communication is presented next, with focus on the types of systems available to individuals with a developmental disability. The review then focuses on communicative competence in individuals who use AAC and strategies for teaching the skills necessary to achieve this competency. A brief discussion of appropriate contexts for teaching new language skills to children is provided. More specific information is then presented on how to teach linguistic competency to individuals who use AAC. The remainder of the review presents research on the use of system/display modifications, naturalistic teaching strategies and behavioralistic teaching strategies in the field of AAC. Within the behavioralistic section, two main teaching strategies are focused upon: discrete trial training and errorless learning. The review discusses the principles of each strategy and how the two strategies are similar. Research is then presented to substantiate the use of the two strategies.

Children with Developmental Disabilities

Definition. A developmental disability is "a severe, chronic disability of an individual, with an onset before 22 years of age, that results in substantial functional limitations in three or more areas of life activity" (ASHA, 2005a, p. 2). Developmental disabilities can be due to mental or physical impairments and include disorders such as autism, intellectual disabilities, and cerebral palsy (ASHA, 2005a; Beukelman & Mirenda, 2005).

Types of developmental disabilities. According to the *Diagnostic and Statistical Manual of Mental Disorders: Fourth Edition-Text Revised* (*DSM-IV-TR*), autism is defined as a qualitative impairment in social interactions, a qualitative impairment in communication, and the presence of restricted, repetitive and stereotyped patterns of behavior, interests and activities. To receive a diagnosis of autism, an individual must evidence a delay or abnormal functioning prior to three years of age in at least one of the following areas: social interaction, language as used in social communication, or symbolic or imaginative play. The *DSM-IV-TR* also requires that the deficits or disturbances cannot better be accounted for by Rett's Disorder or Childhood Disintegrative Disorder in order to receive an autism diagnosis (American Psychiatric Association, 2000, p. 75).

Children with autism may present with a wide range of impairments and deficits ranging from severe (e.g., completely nonverbal) to mild impairments in language and social skills. Deficits for children with autism may affect both receptive and expressive language and may result in a limited vocabulary. For typically developing individuals, language develops through natural concrete experiences. For individuals with autism, receptive language development is dependent on the integration of multiple modalities (e. g., visual, verbal, tactile) with multiple exposures for building a meaningful concept/understanding of an item or word. Individuals with autism also struggle to comprehend abstract concepts which cannot be easily taught through concrete experiences. Expressive language in children with autism may be entirely absent or may appear to be within normal limits. However, some children with autism may present with higher expressive language skills due to echolalia (i.e., echoing the speech of others), but they lack an understanding of the spoken message (Batshaw et al., 2007; Richard, 1997).

Intellectual disabilities, another type of developmental disability, are characterized by significant impairments in intellect and adaptive behaviors according to the American Association on Intellectual and Developmental Disabilities (AAIDD, 2009). Intellectual impairments are typically classified by an IQ score of 70 or less and limitations in adaptive behaviors that can result in deficits in conceptual skills (e.g., language, literacy, and basic concepts), social skills (i.e., pragmatics), and practical/functional skills (e.g., personal care) (AAIDD, 2009). Intellectual disabilities can occur independently of or in conjunction with other developmental disabilities or disorders. For example, individuals with intellectual disabilities may have impaired fine and gross motor skills which can have a detrimental effect on their speech production and intelligibility. Similar to autism, the communicative skills of individuals with intellectual disabilities are highly variable (Batshaw et al., 2007).

Childhood apraxia of speech is an impairment in the ability to motorically program voluntary movements for speech production in the absence of muscle weakness. Although some children with apraxia of speech may have mildly decreased muscle tone or hypo-/hypersensitivity, the majority of speech production errors are not attributable to these conditions. Childhood apraxia of speech is typically associated with intellectual and speech-language impairments. Individuals with apraxia of speech may have difficulty communicating effectively due to the speech and/or language problems (Beukelman & Mirenda, 2005; Velleman, 2003). For these individuals, the context of the speech action is important. Automatic speech requires little planning as it has already been planned multiple times and an existing motor plan can be used to carry out the actions; thus, individuals with apraxia of speech may perform better on these types of tasks. Less automatic, more volitional activities require more complex motor planning and result in increased difficulty for these individuals (Velleman, 2003).

Cerebral palsy is a developmental neuromotor disorder that results from a brain abnormality. Primary characteristics of this developmental disorder are motor difficulties and involuntary movements due to hypertonia (increased muscle tone) or hypotonia (decreased muscle tone) and speech and language impairments. Speech difficulties may occur as a result of the effect of motor difficulties on respiration, vocalization and articulation. Communication and language impairments may also be due to associated medical conditions such as mental impairment (Beukelman & Mirenda, 2005). The most common speech disorder associated with cerebral palsy is dysarthria, but others may be present as well. These speech disorders can range in severity and can greatly affect an individual's intelligibility. Language deficits can vary in severity as well. Children with cerebral palsy can demonstrate both receptive and expressive language impairments resulting in limited vocabularies, poor initiation of interactions, and deficits in syntax, grammar, or literacy skills (Seif Workinger, 2005).

Children diagnosed with developmental disabilities may have a variety of speech and language impairments that can significantly impact their ability to effectively communicate through oral language. For children who have been diagnosed with more severe developmental disabilities, traditional speech-language services targeting oral language may not be entirely effective. Individuals with more severe disabilities may have a limited or absent verbal repertoire, be highly unintelligible, or have other receptive and/or expressive language impairments.

Augmentative systems have been used as an alternative to natural speech to improve an individual's overall communicative competence and to compensate for cognitive, motor and language impairments which may limit a child's ability to communicate. AAC systems can be organized and taught in a variety of ways to improve all areas of language (i.e., semantics, syntax, pragmatics, morphology and phonology). However, research has yet to definitively address the question of which teaching strategies are the most efficient and effective for teaching these individuals language skills, as well as teaching them how to use their AAC systems for communication (Beukelman & Mirenda, 2005; Glennen & DeCoste, 1997; Schlosser, 2003).

AAC Systems

AAC is defined as

> "an area of research, clinical, and educational practice [that] attempts to study and when necessary compensate for temporary or permanent impairments, activity limitations, and participation restrictions of individuals with severe disorders of speech-language production and/or comprehension, including spoken and written modes of communication." (ASHA, 2005b, p.1)

AAC consists of four main components: symbols, aids, techniques, and strategies. Symbols refer to the use of multiple modalities for communication such as graphic or auditory symbols (e.g., signs, facial expressions, line drawings and pictures). The term "aids" refers to the electronic or non-electronic device used to receive or transmit messages. Techniques are the means by which messages can be transmitted (e.g., direct selection), and strategies are the most effective and efficient way of transmitting messages. For instance, strategies can be used to increase communication rate or to aid in formulating a grammatically correct message.

AAC systems can range from low-tech devices (e. g., an alphabet board or a picture-exchange system) to high-tech computerized devices with speaking software. AAC systems can also differ in the types of output. Picture boards and systems such as the Picture Exchange Communication System (PECS) that rely primarily on picture symbols for communication do not have voice output, whereas speech-generating devices (SGDs) such as the Dynavox and Prentke Romich devices provide voice output. Voice output can be digitized speech (i.e., natural speech that has been recorded and stored onto a device) or synthesized speech (i.e., computer-generated speech). Finally, AAC systems can differ in the types of visual displays and the arrangement and number of symbols or vocabulary. Low-tech systems and some SGDs use a fixed display which never changes and have a limited number of symbols available. High-tech systems use a dynamic display which can alternate between visual displays providing virtually unlimited symbol availability (Beukelman & Mirenda, 2005; Glennen & DeCoste, 1997).

Communicative Competence

Communicative competence is defined as the ability to functionally communicate in natural environments and meet daily communicative needs. Communicative competence for AAC users consists of four major skill areas: operational, strategic, social, and linguistic. Operational skills are those necessary technical skills required to efficiently and effectively use an AAC system (e.g., turning the device on, navigating through pages, and programming the device). Strategic skills are compensatory strategies or skills used by individuals to overcome functional limitations or to prevent and repair communication breakdowns. For example, using symbols such as "That was the wrong button" or "That's not what I meant" are strategic skills which an individual can learn to use in order to correct a communication breakdown. Social skills refer to the understanding and use of the social rules of language and interactions. Linguistic skills refer to receptive and expressive language skills of the native language as well as the symbolic code of the AAC system. In order to obtain communicative competence, skills must be developed in all four areas (Light & Binger, 1998).

Contexts for Learning

Communicative competency skills can be developed in a variety of ways. However, the specific combination of linguistic, operational, social and strategic skills varies across individuals depending on the type and severity of the disability, as well as other individual factors such as strengths, weaknesses and personality traits. However, some competence with operational and linguistic skills is necessary before social and strategic skills can be expanded and targeted. For example, individuals must be able to understand and use symbols to convey thoughts and feelings as well as access and select these symbols before they can use them to engage in social exchanges and fix communication breakdowns. As a result, operational and linguistic skills may be the initial focus of intervention (Light, 2003).

According to Alderete et al. (2004), there are four main categories of instructional methods for teaching vocabulary to children: 1) engaging in interactive book reading, 2) direct vocabulary instruction, 3) teaching strategies for using morphological knowledge to learn words, and 4) fostering and increasing word knowledge through "playing with language." Speech-language pathologists can use these methods to teach specific word classes which children with learning disabilities may have difficulty comprehending. Owens (2010) stated that concepts are best taught first through a direct vocabulary instruction method. More specifically, for typically developing children, concepts should be taught in relation to the child and then with "featured" or fronted objects, and finally with non-featured objects. Furthermore, Owens (2010) stated that concepts are best taught in a variety of contexts in order to increase learning and generalization of knowledge.

Joint book reading (JBR) is a natural learning context which is defined as the interaction between an adult and a child while engaged in reading a book. JBR can be used as a tool to develop a variety of language skills, including vocabulary (Ard & Beverly, 2004; Senechal & Cornell, 1993). Joint book reading can be used to build both receptive and expressive language skills (Ezell & Justice, 2005; Justice, 2006). Receptive language skills are targeted by requiring individuals to point to, show or touch something to demonstrate comprehension. Expressive language skills can be built by posing *Wh-* questions to the child and requiring a verbal response in return throughout the reading. Joint book reading can also be used to teach pragmatic skills. Some examples of common social skills which can be easily integrated into a shared storybook experience include topic maintenance, eye contact, and asking questions (Ezell & Justice, 2005).

Specific research studying JBR and AAC has focused on developing literacy skills versus developing language skills such as the ones mentioned above. Research has examined teaching sound-letter correspondence, emergent literacy skills such as directionality of books, identification of main characters and other literacy skills

(Hetzroni, 2004; Johnston & Buchanan, 2007; Light & McNaughton, 2007; Sturm & Clendon, 2004). Limited research is available on the efficacy of JBR as a context for instructing individuals who use an AAC system in order to improve other areas of language. Soto and Dukhovny (2008) examined JBR as a context for improving the expressive vocabulary of a 7-year-old female who used a high-tech AAC device. Results revealed an increase in both the number of different words and the total number of words used. During baseline measures, the subject selected mainly adjectives and nouns; however, generalization probes revealed a decreased use of adjectives and nouns in contrast to the increased use of verbs, articles, pronouns and prepositions. An increase was also found for the use of target words and non-target words related to the story that were not used during baseline, as well as an increase in the use of multi-word utterances.

Teaching Symbol Use to AAC Users

Teaching symbol use to AAC users involves increasing competency in both operational and linguistic areas. Appropriate use of symbols combines semantic knowledge of the symbols with the ability to accurately locate the symbol within the AAC system. System/display modifications are organizational strategies which supplement primary teaching strategies to aid in locating and learning new symbols. The primary strategies which have been explored for teaching symbol use to AAC users can be separated into two main approaches, naturalistic and behavioralistic.

System/display modification. AAC systems can be modified in a variety of ways to facilitate discrimination of symbols and ease of access for symbols. Common manipulations include limiting the number of symbols available on a page, adjusting the size of the symbols on each page, using a dynamic display and color coding symbols.

Limiting the number of symbols on a page can make symbol selection and discrimination easier for individuals, as there is less information for them to process. Adjusting the size of symbols for individuals can be helpful for those with visual or physical impairments which may affect their ability to discriminate between symbols or select smaller symbols. Fixed displays limit the number of symbols that can be used so that individuals may have to combine symbols in abstract ways (e.g., bowl + apple = applesauce). Dynamic displays are beneficial for individuals who may have difficulty with such abstract concepts. The use of a dynamic display allows the same number of symbols to be displayed per page as with the fixed display, but the dynamic display can branch to different pages, increasing the total number of symbols available and, thus, the number of concrete symbol options available (Beukelman & Mirenda, 2005; Glennen & DeCoste, 1997). Color coding is an organizational strategy which has been used to encode messages and teach symbols. Coding is usually related to specific characters such as letters, numbers or symbols (Beukelman & Mirenda, 2005). Color coding can help differentiate symbols and provide a more efficient means of learning and identifying symbols.

Limited research is available regarding the optimal size and number of symbols to use on an AAC system as well as the most effective way to design and organize dynamic displays. Most sources recommend using clinical judgment based on each individual's needs. Several studies have examined symbol organization in terms of color coding for teaching symbols and AAC systems. Results of these studies indicated that variation in color coding of symbols resulted in increased accuracy and decreased reaction time for typically developing individuals and for individuals with a developmental disability

(Wilkinson et al., 2006; Wilkinson et al., 2008). For example, the study conducted by Wilkinson et al. (2006) examined the role of color on the accuracy and speed of symbol selections for 16 typically developing preschool children. Symbols were arranged in an eight-symbol array. Three color conditions were compared: 1) same-color condition (i.e. all symbols were red), 2) guided search condition (i.e., four symbols were red and four were yellow) and 3) unique-color condition (i.e., all symbols were different colors). Participants were presented with a single symbol which was then replaced with a grid display of all target symbols using one of the color conditions. Participants were required to select the single symbol with which they had just been presented. Results of this study revealed that there was a significant difference between the same-color condition and the unique-color condition with the unique-color condition resulting in increased speed and accuracy. No significant difference was found between the guided search condition and the unique-color condition.

Naturalistic AAC intervention. Naturalistic teaching strategies have been employed by AAC interventionists to focus on appropriate use of AAC systems within the AAC user's environment. Kaiser, Yoder, and Keetz (1992) referred to naturalistic strategies as milieu instructions which involve optimizing arrangement of the environment as well as selecting specific intervention targets and offering specific prompting strategies to interventionists. Hart (1985) established three components of milieu intervention which included time delay, incidental teaching, and mand-model instruction. Other naturalistic interventions include Aided Language Modeling (ALM) and the System for Augmenting Language (SAL).

The time delay strategy encourages self-initiated communication. The majority of studies investigating the use of time delay or expectant time delay focus on teaching requesting behaviors to individuals with developmental disabilities (Glennen & Calculator, 1985; Halle, Baer, & Spradlin, 1981; Kozleski, 1991). These strategies incorporate the use of placing a desired object or activity within sight of the AAC user and then looking at the student expectantly and waiting for a set period of time (e.g., 10-60 seconds) for the user to initiate the request. Both Halle et al. (1981) and Kozleski (1991) found time delay to be an effective naturalistic strategy for teaching requesting behaviors in individuals with developmental disabilities.

Incidental teaching is also based on a learner initiated approach to communication. Incidental teaching involves the AAC user initiating a communicative utterance followed by an expansion from the communication partner to provide a model for the child (Reichle, Hidecker, Brady & Terry, 2003). As described in the time delay strategy, incidental teaching also involves manipulating the environment to create communication opportunities. Incidental teaching has been found to increase a variety of communication functions in children with autism (McGee, Krantz, & McClannahan, 1985, 1986; McGee, Morrier, & Daly, 1999).

The mand-model technique, although still a naturalistic strategy, provides a more specific prompt (e.g., "What do you want?" or "What is this?") to elicit a desired behavior. If the AAC user does not respond to the mand, the interventionist models the desired behavior for the child to imitate (Reichle et al., 2003). The technique involves manipulating the environment to highlight objects of interest. It is a teacher initiated strategy which has been found to be effective in teaching a variety of communicative functions, specifically requesting behaviors (Halle, 1987).

Finally, aided language modeling (ALM) is a naturalistic teaching intervention that requires the facilitator or communication partner to point to key symbols on the AAC device while speaking in order to provide both verbal and visual input using the individual's AAC system. ALM teaches both understanding and use of graphic symbols (Beukelman & Mirenda, 2005). This strategy has been shown to be effective for teaching symbol comprehension and symbol production to children diagnosed with a developmental disability with little to no functional speech (Binger & Light, 2007; Dada & Alant, 2009; Drager et al., 2006).

Colgan (2009) examined the effectiveness of the naturalistic strategy of aided language modeling on increasing social interactions in three children with autism who used an AAC system within the context of a joint book reading activity. Specific skills targeted were commenting, asking questions, and the use of repetitive lines. Participants were presented with a 14-symbol grid display on his/her high tech AAC device. Symbols represented comments, questions, and repetitive lines appropriate to the target books. For each joint book reading interaction, the researcher followed a script outlining the specific models used for each book. The same communication board used on the participants' AAC systems was also displayed on a SMART board which the researcher used to model, in conjunction with a verbal reproduction of clients' selections on their devices. Results indicated that one participant showed consistent increases in responding to questions and using repetitive lines during the joint book reading. Of the remaining two participants, one showed improvement in responding to questions and using repetitive lines, and the other showed improvement with all three interactions. However, performance for the last two participants was variable throughout the study. This study demonstrated that ALM was effective for teaching more functional vocabulary versus only standard nouns, verbs, and requests. However, the author did not compare ALM with more structured approaches. More consistent gains may have been seen if behavioralistic techniques were implemented or if the number of choices on the grid had been systematically manipulated.

Behavioralistic AAC intervention. Although naturalistic strategies have been proven to be effective in teaching communication to AAC users, some individuals with more severe impairments of cognition and language may require a more direct approach to teaching specific skills. Direct instruction in AAC intervention incorporates the use of more specific cues in a distraction-free environment with extensive intervention opportunities (Reichle et al., 2003). Direct instruction differs from naturalistic intervention in that it "occurs in environments different from or in addition to environments in which the target behavior will be used in order to achieve large numbers of highly discriminable instructional opportunities" (Reichle et al., 2003, p. 450). Direct instruction includes behavioralistic strategies such as discrete trial training and errorless learning. These two strategies incorporate behavioralistic concepts such as stimulus fading, stimulus shaping, graded choice and the use of a most to least hierarchy of cuing. Stimulus shaping involves progressively altering the physical features of a symbol across successive sessions to enhance the symbol features. Stimulus fading gradually reduces enhancement of a symbol across successive sessions. Graded choice presents symbols in their final physical forms but controls the ability of individuals to select the symbols.

Cuing hierarchies are another common teaching strategy and can be used in a most-to-least hierarchy or a least-to-most hierarchy. In the most-to-least hierarchy, the least intrusive cue that will guarantee an accurate response is initially used and then systematically reduced. The goal of this hierarchy is to reduce errors. In the least-to-most hierarchy, the initial prompt is the natural cue within the learner's environment that will eventually serve as the signal for a communicative act. If the individual does not respond to the natural prompt, cues are systematically increased to become more intrusive. This hierarchy prevents individuals from becoming over-reliant on prompts but may also increase the time from the initial cue to the performance of the desired communicative act (Reichle et al, 2003). Research has shown that such strategies are effective during direct instruction and can be used to supplement less intrusive intervention strategies such as the naturalistic teaching strategies (Durand & Carr, 1991; Reichle et al., 2003; Wacker et al., 1990).

Discrete trial training. Discrete trial training (DTT) is a variant of an applied behavior analytic procedure teaching strategy. Each discrete trial lasts for a short period of time and consists of five main parts: cue, prompt, response, consequence, and intertrial interval. A cue is a concise, clear instruction or question presented to the client. Prompts are delivered simultaneous with cues or immediately following (e.g., modeling the response or guiding the student to perform the response). The point of the prompt is to help the individual respond correctly to the instruction or question. Response refers to the correct or incorrect reply that the client provides in answer to the cue and prompt. Consequence refers to the action or response of the clinician to reinforce accurate responses or to signal that the response was incorrect. Intertrial interval is the brief period between the consequence and deliverance of the next cue (Ghezzi, 2007; Smith, 2001). DTT has been shown to be effective for teaching imitation, receptive and expressive language (i.e., vocabulary), conversational skills, grammatical structures, play skills, and social-emotional skills (Downs et al., 2007; Smith, 2001).

Downs et al. (2007) conducted a study examining the effects of DTT for improving a variety of skills with children diagnosed with a developmental disability. Participants for this study were 12 children who were enrolled in a developmental preschool. Participants were randomly assigned to a control group or an experimental group. Mean ages for the groups were 47.50 and 48.83 months, respectively. The independent variable for this study was the use of a DTT instruction format for the experimental group. Dependent variables were the effect of DTT instruction on cognitive, language, adaptive, behavioral, and social-emotional functioning. The study was conducted in three phases: pre-test, intervention and post-test. Pre-test measures included administering a battery of tests to assess levels of functioning for all dependent variables. Intervention was conducted in one 10-15 minute pull-out session per day per child, with an average instruction time of 1.30-1.58 hours per week. DTT instruction focused on receptive/expressive language skills, socialization, pre-academics, daily living skills, imitation and fine motor skills. Post-test measures were administered following eight months of intervention using the same battery of tests as during pre-test. Overall results of the study revealed that individuals in the DTT experimental group showed significant gains in adaptive behavior in the areas of communication, socialization, daily living skills and overall adaptive behavior/functioning. Students in this group also were rated by their caregivers as exhibiting higher levels of adaptability, social skills and social behaviors as well as lower levels of inappropriate social behaviors. The overall results indicated that DTT was potentially an effective treatment for individuals with a developmental disability (Downs et al., 2007).

The core of DTT is controlling the teaching situation. This includes controlling the number of opportunities that the individual has to respond as well as controlling the events which happen before, during, and after the individual's response to the learning task. Additional control is provided by the utilization of prompts in that the prompts may provide the appropriate verbalizations or actions if the individual does not respond. The prompting hierarchy also uses the least intrusive procedure and is the recommended strategy for teaching a new skill. The control offered by DTT and the fact that it uses a least-to-most prompting hierarchy closely relates DTT to an errorless learning teaching procedure (Ghezzi, 2007). Although DTT is related to errorless learning, there is little research exploring errorless learning as an effective strategy for teaching individuals with developmental disabilities.

Errorless learning.

Definition. Errorless learning has been defined as "a set of teaching strategies designed to reduce incorrect responding as the student gains mastery over the work materials" (Mueller et al., 2007, p. 691). Errorless learning is a variant of operant conditioning techniques. It focuses on the component which is meant to be taught, the reinforcers which will be used to maintain or change a specific behavior and the system used to control the administration of the reinforcers (Schimek, 1983). The construct for errorless learning is similar to that of DTT in that it centers on controlling the situation in order to ensure success for the individual completing the task. Specifically, it controls the introduction of both the correct and the incorrect stimuli in such a way that it essentially forces an individual to select only the correct choice. Therefore, only one behavior is being constantly reinforced. This allows a response pattern or a routine to develop around the correct choice before the incorrect choice is ever introduced (Schimek, 1983; Storm & Robinson, 1973).

According to Mueller et al. (2007), errorless learning is an ideal teaching strategy for children with pervasive developmental disorders (PDD). This strategy limits incorrect responses that can become a problem with these children's rigid adherence to routines and problematic behaviors in response to failure or difficulty learning a new task. Errorless procedures used for research have previously consisted of one of the following six techniques: stimulus fading, stimulus shaping, graded choice, delayed prompting, superimposition with stimulus fading and superimposition with stimulus shaping (Mueller et al., 2007).

Stimulus fading consists of establishing a response to the correct choice without exposure to the incorrect stimuli and then gradually presenting (i.e., fading in) an incorrect choice so that, eventually, both choices are equally presented in terms of intensity, size, shape, color, and other physical characteristics. Stimulus shaping introduces two different choices and gradually changes these stimuli over time in such a way that the final choices have different physical characteristics from the initial stimuli presented. Graded choice or response prevention presents both stimuli throughout intervention in their final form, but the ability to select the incorrect choice is limited. For instance, two symbols may be presented on a display screen, but only one symbol may be activated. Delayed prompting consists of providing an initial physical prompt (e.g., pointing) as soon as the stimulus is presented. There is then a systematic increase in time between the presentation of choices and the onset of the prompt. The final two errorless learning teaching strategies are superimposition of stimulus fading and superimposition of stimulus shaping. Instead of making physical changes to the actual stimuli, a prompt is superimposed over the choice and changes are gradually made to this prompt over time. For example, a known symbol is superimposed over an unknown symbol, and the known symbol is gradually faded out until only the unknown symbol remains (Mueller et al., 2007).

Effectiveness. As errorless learning is a variant of operant conditioning techniques, this type of teaching strategy has been researched almost solely from a behavioral approach and has not been explored as a teaching tool for language development. However, research supporting DTT substantiates the idea that behavioral approaches can still be beneficial for teaching new language skills. DTT has been proven as a successful intervention technique for children who have a developmental disability. Since errorless learning and DTT share a similar theoretical construct, it stands to reason that errorless learning may also be a successful teaching strategy. Children with developmental disabilities may require structured activities and may develop routines which they later have difficulty adapting or changing. Typical "errorful" learning (i.e., trial-and-error learning) allows children the opportunity to learn an incorrect response pattern or to perseverate on an incorrect response. Smith (2001) stated that when children with autism are placed in such a teaching situation they "are likely to experience frustration…and, understandably, they may react to such frustration with tantrums and other efforts to escape or avoid future failures" (p. 86). If a child struggles with changing or adapting a routine, it may be difficult to teach the correct response once an incorrect one has been chosen and a pattern or routine established. Therefore, an errorless learning strategy may be beneficial for this population as it would eliminate the possibility of children forming patterns or routines around incorrect responses. Errorless learning would teach the correct response only and allow children to develop a routine around this response. Afterwards, incorrect responses can be faded in for a more natural learning context.

Errorless learning has been studied and found to be effective for treating disorders more often found in the adult population, but research is limited on the efficacy and use of this intervention strategy with children and especially with children who use AAC. Schimek (1983) conducted a study that examined the efficacy of errorless teaching with one child. It specifically looked at errorless learning for teaching visual and auditory discrimination of digraphs to an eight-year-old female with a learning disorder. The child was presented the digraph with a visual cue and asked to repeat its sound. The visual cue was gradually faded to allow for errorless discrimination. The example provided in the study dealt with the teaching of *th*. The visual cue provided originally was a picture of a large thumb. This cue was gradually faded to a picture of a hand with a normal sized thumb and then to no cue. This study found that the errorless intervention strategy efficiently and effectively increased the accuracy of the child's discriminatory abilities (Schimek, 1983).

In a study by Storm and Robinson (1973), an errorless learning teaching strategy was found to be effective for teaching color discrimination to children. Twelve children between the ages of four to seven years were included in this study. The study examined whether children could errorlessly discriminate between a correct choice (i.e., S+) and an incorrect choice (i.e., S-) when taught using a method other than fading. Children for this study were divided into three groups. Participants in Group 1 were first given a set number of trials with only exposure to the correct choice (i.e., S+), then a set number of trials with exposure to both choices but only the capability to select the S+ choice, and, finally, a set number of trials with exposure and selection access to both choices. Participants in Group 2 were exposed to all three conditions but were given an increased exposure length to the first condition. Group 3 was the control group and was exposed and given access to both choices from the start. Results revealed a significantly lower level of errors for participants in the first two groups than participants in the last group, indicating that a majority of those participants learned to discriminate errorlessly with an intervention technique other than fading. The results provided evidence that errorless learning can occur without "presenting S- immediately in a discrimination task nor varying S- away from S+ along one or more physical dimensions" (p. 407). The authors offered several reasons for the use of a graded choice strategy over a fading strategy, including the fact that use of a graded choice method is not dependent on the behavior of the client and allows the S- stimuli to be introduced for any length of time for discrimination training without errors occurring (Storm & Robinson, 1973).

To date, there is little research studying errorless learning as an intervention strategy for AAC. In a recent study conducted by Quach and Beukelman (2010), errorless learning was examined in order to determine its efficacy for teaching operational skills for an AAC system to typically developing children. Participants in this study were 21 six- and seven-year-olds. Other selection criteria for this study were a) having normal or corrected vision, b) having functional hearing, c) being a native speaker of American English, d) having no identified language, learning, cognitive or fine motor disabilities, e) having no experience using AAC devices and f) having reading skills equivalent to Grade 1. Participants were randomly assigned to one of two instructional methods: corrective feedback (CF) and dual-screen guidance (DSG). Controls were put in place for age when assigning children to groups.

Intervention took place in four stages: practice, intervention, generalization and maintenance. Practice measures presented individuals with a list of sentences. Sentences were presented using both verbal and visual stimuli (written and graphic symbols). Participants were then asked to select the symbols matching the presented sentence. Similar procedures were used during the intervention portion with a different set of sentences. Children in the CF condition allowed for errors to be made and the following cues to be used: natural cue (showing a picture), constant time delay, and pointing to the AAC device. If an error was made, the appropriate response was modeled immediately following the child's attempt. For children in the DSG condition, if there was no response after three seconds, the participant was guided to the appropriate selection (i.e., was not given the chance to make an error). Practice and intervention portions were conducted together during three sessions. The fourth session measured generalization by presenting a third list of sentences to the participants. Maintenance was assessed two weeks later in one session using the same sentence list as used during generalization (Quach & Beukelman, 2010).

Results of the study were computed using statistical analysis and revealed that children in both age groups from the DSG condition achieved 100% accuracy with the instructional (practice) sentences and achieved this accuracy faster than children in the CF condition. Children in both conditions exhibited learning during the intervention sessions and achieved a level of proficiency in using the AAC device by the third session. Generalization measures and maintenance measures indicated no significant differences between the children in the two instructional groups or between the two age groups. Overall, results revealed that the seven-year-olds performed more accurately on average than the six-year-olds. Although no difference was noted between the two instructional conditions for seven-year-olds, there was a 15% difference in accuracy between the two methods for six-year-olds during each intervention session. The results of this study substantiate errorless learning as a potential teaching strategy for individuals who use AAC. However, more research is necessary to validate this method in terms of its efficacy for instructing individuals with disabilities and for teaching skills in other competency areas such as linguistic skills (Quach & Beukelman, 2010).

Conclusion

This review of the literature has revealed several important factors. First, research has shown that children with developmental disorders often have accompanying significant communication impairments. AAC systems have been shown to be effective for increasing communication for these children. Furthermore, research has supported the use of manipulatives and joint book reading as appropriate contexts for teaching new language skills to children and improving overall communicative competence. There are several teaching strategies which have proven effective for teaching communicative competence to individuals using an AAC system. Color coding is an effective supplemental organizational teaching strategy for improving symbol knowledge and operational competency in individuals who use an AAC system. The two main styles of teaching strategies are naturalistic and behavioralistic. Naturalistic teaching strategies are strategies such as milieu teaching, incidental teaching and aided language modeling and can be used to target a variety of skills including symbol acquisition and expression. Behavioralistic teaching strategies are structured intervention strategies which can be used to target specific skills in a controlled manner. DTT is one such strategy that research has established as an effective means of teaching language skills and for increasing vocabulary/symbol knowledge for children who use AAC systems. The control over the teaching situation and the least-to-most cuing hierarchy used in DTT closely relates this procedure to errorless learning.

However, this review of the literature also revealed that the research examining and supporting errorless learning as a teaching strategy for children who use an AAC system for communication is limited. Research has shown that errorless learning is effective for teaching discrimination tasks to both typically developing children and children with a learning disability. More recent research has explored the use of errorless learning for teaching AAC operational skills to typically developing children and found that children in the errorless learning group performed better than those in a typical errorful learning group. However, as DTT and errorless learning share several key features, errorless learning may also prove to be an effective teaching strategy for individuals with a developmental disability, similar to DTT. Errorless learning has never been examined for teaching areas of communicative competence besides operational skills and has been studied in limited populations. In order to determine the efficacy of errorless learning as a teaching strategy for children with a developmental disability and for increasing communicative competency, further research is needed.

Purpose of the Study

Due to the lack of research in these areas, the current study sought to examine the effectiveness of errorless learning for teaching new core vocabulary, specifically positional concepts and comments, to children with a developmental disability who used an AAC device. Colgan's study (2009) evaluating the use of aided language modeling for teaching symbol acquisition lends support to the use of naturalistic strategies for teaching more functional vocabulary than just nouns to children with a developmental disability. The current study further examined the teaching of more functional vocabulary (versus simple nouns) as well as the use of behavioralistic strategies for teaching this vocabulary. The current study also employed color coding as a supplemental strategy to aid in visual discrimination of symbols. Manipulatives, joint book reading and scripted exchanges were used to present the new vocabulary in a structured, meaningful context. Specifically, the study addressed the following questions:

1) To what extent do children with autism improve symbol acquisition skills when instructed using an errorless learning strategy?
    a. Is errorless learning effective for improving symbol acquisition (i.e., correct symbol selections) and/or communicative attempts (i.e., total symbol responses, correct and incorrect) within an activity similar to the teaching context?

b. Is errorless learning effective for improving symbol acquisition and/or communicative attempts within a new context/activity?

c. Is errorless learning effective for improving initiation and independence of responses for newly acquired symbols?

2) Is an errorless learning teaching strategy more effective for improving symbol acquisition of concepts or comments in children with autism?

Chapter III

Methodology

Participants

Four children receiving services from the Eastern Illinois University Speech-Language Hearing (Clinic) were recruited as participants for this study. Internal Review Board (IRB) approval and informed consent were obtained from the parents prior to the start of the study (see Appendices A and B). Participants were selected based on the following inclusionary criteria: (a) a previous diagnosis of a developmental disability, (b) use of a high tech AAC device with voice output, (c) the ability to communicate simple wants and needs, (d) the ability to directly select symbols from a grid display of ten symbols, (e) corrected or uncorrected vision within normal limits or within limits that does not affect the ability to select symbols, (f) hearing within normal limits, and (g) Standard American English as their primary language.

Subject 1 was a seven-year, five-month-old male who had been receiving services at the Clinic since 2006. He was previously diagnosed with autism, motor dysphasia, and sensory integration dysfunction in 2005 by a pediatric psychiatrist. It was reported that Subject 1 took medication to improve his sleep but was otherwise in good health. He received early intervention services until he was three. In addition to attending the Clinic, he received speech-language and occupational therapy services at his elementary school where he was enrolled in first grade. His receptive and expressive language skills were estimated to be at 16-24 month-old developmental level by parent responses to the *Macarthur-Bates Communicative Development Inventories: Words and Gestures* (Fenson et al., 2007) and his most recent clinical supervisor. Subject 1 was using a Dynavox IV high tech AAC device to communicate during therapy sessions at the Clinic; however, he had no device outside of the Clinic. It was reported by the current clinician that a Picture Exchange Communication System (PECS) was used previously in other environments but was no longer being used. Subject 1 demonstrated the ability to communicate basic wants/needs and use two-symbol combinations using the AAC device.

Subject 2 was a five-year, seven-month-old male who had been receiving services at the Clinic since 2009. He was previously diagnosed with autism by a pediatric psychologist in 2007. Subject 2 had a history of recurrent ear infections resulting in placement of several sets of pressure equalization tubes; however, the last report of his hearing was within normal limits. He was enrolled in an area elementary school where he attended a resource classroom in the morning and a regular education kindergarten classroom in the afternoon. Subject 2 received the support of a one-on-one aide at school and also received additional speech-language services. Behavioral feeding intervention and occupational therapy services were also provided at an area medical clinic. Subject 2 used both verbal language and a Dynavox V to communicate wants/needs across all environments. Subject 2 demonstrated the ability to use his AAC system to request desired objects and activities, comment and construct simple sentences. However, oral receptive and expressive language skills were delayed and at a developmental level of a sixteen-month-old based on parent responses to the *Macarthur-Bates Communicative Development Inventories: Words and Gestures* (Fenson et al., 2007). His most recent clinical supervisor, however, reported language skills consistent with a three-year to four-year-old level with the use of his AAC system.

Subject 3 and Subject 4 were twin eight-year, one-month-old females who were also receiving services at the Clinic. They received services at the Clinic since 2005. They were diagnosed with moderate to severe autism by a medical professional in February of 2002. They attended second grade at an area elementary school where they each had a one-on-one aide. They also received additional physical therapy, occupational therapy, and speech-language services at school. Both took medication for hyperactivity two times daily. Subject 3 used a Dynavox IV high tech AAC device for communication. Subject 4 relied on a Dynavox VMax high tech device for communication. They consistently requested objects and activities, efficiently and effectively navigated through the device, and combined symbols to construct simple utterances. Both subjects were nonverbal and reportedly functioning at a three-year to four-year-old developmental level according to the clinical supervisor. Subject 3 was administered the *Peabody Picture Vocabulary Test-Fourth Edition* (*PPVT-4*) (Dunn & Dunn, 2007) by another clinician while this study was being completed and obtained a standard score of 20 and an age equivalency of <2:0, indicating significantly delayed receptive one-word vocabulary skills.

Research Design

The current study employed a single subject, ABABA withdrawal design. The study consisted of the following phases: baseline, intervention, withdrawal, reinstatement of intervention, and withdrawal. Probes for maintenance and generalization occurred during the withdrawal phases. Sessions conducted during all phases of the study took place twice each week and lasted for approximately ten minutes per session. Baseline measures evaluated skills for a two-week period. Intervention was conducted in two, four-week periods with a six-week withdrawal period in between which allowed for generalization and maintenance probe measures. The independent variable for this study was the application of the errorless learning intervention strategy targeting concepts or comments on an AAC device during a scripted book-reading activity or a scripted activity using manipulatives. Treatment was provided by two trained student clinicians. The dependent variables were 1) the acquisition of new concepts or comments within an activity similar to the treatment context, 2) generalization of symbol acquisition to new activities/contexts, and 3) the amount of assistance required during instruction of new vocabulary. Data collection was completed during weekly intervention sessions, weekly probes, and generalization and maintenance probes by the researcher or a second trained clinician.

Each participant's communication display consisted of a total of eight or ten symbols. Symbols selected were consistent across participants for either concepts (eight symbols) or comments (ten symbols). Communication displays targeting concepts contained four target symbols that were taught during intervention phases (i.e., teaching vocabulary) as well as four symbols from a secondary vocabulary set (i.e., foil vocabulary). Displays targeting commenting contained five target symbols from the second teaching vocabulary set and five target symbols from the second foil vocabulary set. Symbols were iconic symbols available on Dynavox-Mayer AAC systems. The following tables depict all target vocabulary from both sets of teaching vocabulary and foil vocabulary:

Table 1

Concept Vocabulary Targets for Intervention Phases

Concepts	
Teaching Vocabulary	Foil Vocabulary
Under	Up
In	Down
On	Out
Open	Close

Table 2

Comment Vocabulary Targets for Intervention Phases

Comments	
Teaching Vocabulary	Foil Vocabulary
Yes	Fun
No	I like
Yucky	I don't like
That's silly	Look
Uh oh	Wow

Concept vocabulary was selected based on a developmental hierarchy of positional concepts. No concepts targeted were above the level of a 36-month-old for the teaching set of vocabulary or above the level of a 60-month-old for the foil set of vocabulary (Owens, 2008, 2010). Comments were selected based on those readily available on the device from the Gateway 40 pages and those that would be functional and applicable to a variety of contexts. For instance, although contracted negatives are a higher level language skill developing between 39-56 months (Owens, 2010), the symbol for *I don't like* was a standard AAC system symbol on both Subject 3's and 4's devices. The iconic pictures also supplemented the written text to aid in understanding what a symbol meant.

Concepts were taught during teaching sessions using physical objects in play-based activities. Concept symbol acquisition was measured during weekly probes and maintenance probes using a similar context. Objects used included, stuffed animals, blocks, and balls. Generalization probes for concepts were in the form of joint book reading sessions. A book from the *Spot* series, written by Eric Hill, served as the generalization context for the symbol acquisition of concepts. A book from the *David* series, written by David Shannon, served as the teaching context focusing on the acquisition of comments and responses to questions during teaching sessions. Weekly probes and maintenance probes were measured using a second book from the same series. One book was randomly assigned to be used during measurement of the dependent variable during baseline and probe measures throughout the study. The remaining book was randomly assigned to serve as the treatment context. Generalization probes for comments were conducted in play-based activities using objects such as bubbles, balloons, and Mr. Potato Head dolls (see Appendix C for a list of all materials).

Dependent variables. As previously stated, there were three dependent variables being measured. The primary dependent variable was the ability to use concepts or comments accurately/appropriately when presented with the full grid display during a scripted activity. This variable was measured during baseline sessions as well as during weekly probes in the intervention phases and during maintenance probes in the withdrawal phases. A secondary measure was the ability of participants to generalize the use of target vocabulary during play-based or joint book reading activities. This variable was measured through generalization probes collected during the withdrawal phases. One generalization probe was collected during the first week of the withdrawal phases to assess the ability of subjects to generalize learning immediately following intervention. Two other generalization probes were collected during weeks five and six of the withdrawal phases in order to assess generalization skills over a period of time. As previously stated, concept generalization probes were conducted for target vocabulary during joint book readings, and comment generalization probes were conducted during play-based activities. Data for the primary dependent variable (i.e., symbol acquisition) recorded number of communicative attempts (i.e., the total number of responses regardless of accuracy) as well as the number of accurate responses made by the participant when given no assistance and presented with the full grid display during a scripted reading of the non-taught book or a scripted exchange with non-taught objects. Accuracy was judged on three behaviors: 1) direct selection of a target symbol, 2) head nod or head shake to indicate "Yes" or "No," and 3) production of a consistent verbalization to represent a single concept. Data were also collected on any spontaneous and appropriate responses made in addition to the target responses being elicited throughout the scripted exchanges. Data were collected in a similar manner for generalization probes.

The final dependent variable examined the amount of assistance (e.g., general visual cue, specific cue, or hand-over-hand assistance) needed for subjects to use the target symbols during errorless learning teaching sessions throughout the intervention phases. Data for the final variable recorded the amount of support required to obtain the accurate response for each scripted joint book reading or scripted exchange using manipulatives during the ten minute teaching sessions.

All sessions were videotaped using the digital recording system already in place within the Clinic, as well as with a hand-held digital camera to provide a clearer visual representation of symbol selections and support provided. All sessions were coded using data forms to record the accuracy of symbol selections for the primary dependent variable (i.e., symbol acquisition) and the generalization dependent variable, as well as the amount of support necessary to select symbols for the third dependent variable. These data forms were completed during repeated viewings of all videos in order to accurately document the subjects' performance during treatment and probe measures (see Appendix D for example data sheets).

Reliability was assessed using inter-rater reliability measures. The two raters, the researcher (i.e., primary coder) and a clinician (i.e., secondary coder) trained in all data collection techniques, reviewed 20% of the videos separately. An agreement index was used to compare the data collected by both raters and revealed 95% inter-rater reliability overall. More specifically, reliability was 98% for comments and 90% for concepts.

Study phases. The study consisted of a total of five phases: one baseline phase, two treatment phases, and two withdrawal phases. Each phase is discussed in further detail below. A visual timeline of the study is available in Appendix E.

Baseline phase. During the baseline phase, the treating clinician presented the previously assigned book or objects to each participant for a period of two weeks, two sessions per week, until a consistent baseline measure was achieved. Subjects were presented with all target symbols designated for the teaching and foil vocabulary sets. Symbols were arranged in an eight item grid display for concepts and a ten item grid display for comments. Subjects 1 and 2 participated in baselining of concepts, and

Subjects 3 and 4 participated in baselining of comments. Data were collected on the subjects' use of the target symbols when given no support from the clinician during a scripted joint book reading or play-based activity in order to obtain a baseline measure of vocabulary knowledge. The scripted exchange presented three opportunities to use each of the eight or ten target symbols (i.e., 24 total opportunities for concepts and 30 total opportunities for comments). If subjects did not respond or responded incorrectly, the treating clinician provided a verbal model of the correct response. No visual models were provided to avoid any teaching which may be associated with modeling the appropriate selection on the AAC devices. The number of correct and incorrect responses for the 24 or 30 opportunities were calculated and plotted on single subject graphs for each participant.

Intervention phases. Following completion of the baseline phase, intervention sessions were conducted for two, four-week periods: Phase 1 and Phase 2. Subjects received approximately two hours of intervention per each four-week intervention period for either concepts or comments.

During each teaching session, the subjects engaged in a play-based activity for concepts and a joint book reading activity for comments. Each session was targeted in the form of a scripted exchange. The script consisted of four main components: 1) the treating clinician read the text present in the book or drew attention to the position of the object, 2) the treating clinician made a comment or asked a question about the text, a related picture, or the position of the object, 3) the subject responded to the clinician's question, and 4) the clinician reinforced and/or expanded on the subject's response. A scripted exchange was completed one time during a single treatment session; however, each scripted exchange provided multiple exposures to each target vocabulary (i.e., subjects received four opportunities for each target concept or comment per session) (see Appendix F for examples of scripted exchanges).

Two different communication displays were used during the intervention phase of the study. The communication display used during errorless learning teaching sessions displayed only one symbol at a time. This display presented only the target symbol expected and/or appropriate for responding to a question or comment in order to eliminate any opportunities for the subjects to respond incorrectly. Activation of this symbol automatically scrolled the display to the appropriate response for the next question. The second communication display was used during the weekly probes and was identical to the display used during the baseline phase. For each dependent variable, the target symbols remained consistent across participants. Symbols were consistently color-coded according to the Fitzgerald Key color coding system. This coding system was chosen since the Dynavox Gateway 20 and Gateway 40 communication pages are coded using this system, and it was thought that consistency between the intervention pages and the Gateway pages would result in greater carryover of symbol knowledge. In the Fitzgerald Key coding system, verbs are green, comments are pink, and descriptors are blue. As the Fitzgerald Key does not account for concepts as a separate color, the following coding of positional concepts was determined. The target vocabulary *open* and *close* were shaded green as both can also be used as verbs. The remaining positional concepts were determined to fit best in the descriptor category and, therefore, were coded blue. Comments remained pink in accordance with the key. *Yes* and *no* responses to questions were coded purple to aid in discrimination from comments. Location of symbols within the display remained consistent across displays and subjects as well.

Throughout the intervention activities, the clinician followed the script in order to pose certain questions at set intervals to the subjects. Following each question, subjects were given the opportunity to respond independently. If an independent response was not obtained, support was provided to the subjects following a least-to-most cueing hierarchy. During the errorless learning teaching sessions, support consisted of 1) restating the question and providing a general visual cue (i.e., pointing to the device), 2) restating the prompt and providing a specific visual cue (i.e., pointing to the symbol), and finally 3) restating the prompt and providing hand-over-hand support. Once the subjects selected the appropriate symbol for any point in the scripted exchange, the display automatically scrolled to the next appropriate response. As the subjects demonstrated success with one symbol (i.e., three of four independent, accurate selections across three consecutive sessions), a symbol from the foil vocabulary set was gradually introduced. If a subject demonstrated success with one symbol during the weekly probes (i.e., three of three independent, accurate selections), the full grid display was incorporated for that symbol during the teaching sessions. These criteria allowed for the most functional practice and clinically relevant use of the target vocabulary as the subjects' knowledge and skills improved.

Withdrawal phases. Treatment was withdrawn for a six-week period following both Phase 1 and Phase 2. One generalization probe was conducted during week one, and two additional generalization and maintenance probes were conducted during weeks five and six of the withdrawal periods. Probes were conducted for ten minute sessions.

Generalization probes were conducted for individuals learning concepts in the form of joint book reading activities. Generalization probes for subjects learning new comment vocabulary were conducted in play-based activities such as bubbles, balloons, and Mr. Potato Head. Maintenance probes were conducted for both groups using the same context as was used during baseline and weekly probes (i.e., manipulatives for subjects learning concepts and joint book reading for subjects learning comments).

Treatment consistency. Treatment consistency was evaluated by reviewing a random selection of approximately 20% of the treatment videos to ensure that scripted exchanges and cuing and support were provided consistently. The researcher evaluated each randomly selected video to determine if the treating clinician followed the scripted exchange consistently for each activity. The consistency with which the cuing hierarchy was used for both joint book reading exchanges and play-based activities was evaluated as well. The treatment consistency percentage was calculated and found to be 100% for each condition, indicating that all components of the scripted exchange were present and the cuing hierarchy was followed accurately.

Data Analysis

Data for all three dependent variables were collected through the review and analysis of each recorded session. For the symbol acquisition and generalization dependent variables, data were recorded during baseline, weekly probes, maintenance probes and generalization probes. Subjects' responses were coded as correct if the subject selected the desired target symbol and were coded as incorrect if any symbol other than the target symbol was selected. For Subjects 3 and 4, data were also coded according to whether the incorrect symbol selected was an appropriate, alternative response or an inappropriate response. Data for the third dependent variable were coded for the amount of support (i.e., the level of the least-to-most cuing hierarchy) required for the subjects to select the target symbol at each opportunity during the scripted exchanges. These data were also used to track subjects' progress along the graded choice continuum.

Data collected for all three dependent variables were then recorded in tables and converted to graphs to allow for visual inspection of the data. These graphs allowed for comparison of the dependent variables across all phases of the study and across subjects to determine if any trends arose from the data.

Chapter IV

Results

A single subject, ABABA withdrawal design was used to evaluate the effectiveness of errorless learning for teaching symbol acquisition of concepts and comments to four children with autism who used an augmentative and alternative communication device. Data were collected on three dependent variables over a period of three months. Visual analysis was used to analyze the data to answer the following research questions:

1) To what extent do children with autism improve symbol acquisition skills when instructed using an errorless learning strategy?
    a. Is errorless learning effective for improving symbol acquisition (i.e., correct symbol selections) and/or communicative attempts (i.e., total symbol responses, correct and incorrect) within an activity similar to the teaching context?
    b. Is errorless learning effective for improving symbol acquisition and/or communicative attempts within a new context/activity?
    c. Is errorless learning effective for improving initiation and independence of responses for newly acquired symbols?
2) Is an errorless learning teaching strategy more effective for improving symbol acquisition of concepts or comments in children with autism?

Acquisition of Concepts

The results for Subjects 1 and 2 are detailed below and are organized according to the three dependent variables contained in the first research question listed above. Symbol acquisition within a scripted activity similar to the teaching context was measured across baseline, teaching and withdrawal phases through a series of weekly probes and maintenance probes. For all probes, Subjects 1 and 2 were presented the full grid display of eight symbols (i.e., the teaching vocabulary and foil vocabulary outlined in Table 3.1). Subjects were provided a total of 24 opportunities (i.e., three opportunities for each target symbol) to demonstrate learning for all target vocabulary. Data points for each opportunity were plotted based on whether a subject 1) showed no response, 2) responded incorrectly or 3) responded correctly. No support or cuing was provided during these probes. The ability of subjects to generalize symbol acquisition to a new context/activity was measured during the withdrawal phases through generalization probes using these same procedures.

The final dependent variable in this study examined the ability of subjects to improve initiation and independence of responding. This was measured through the amount of assistance and cuing subjects required to select each target symbol during errorless learning teaching sessions in Phase 1 and Phase 2. The level of assistance and cuing was based upon the four-tiered cuing hierarchy used during all errorless learning teaching sessions throughout Phase 1 and Phase 2.

Subject 1.

Acquisition. As previously stated, positional concept symbol acquisition was measured using data collected during baseline, weekly probes, and maintenance probes. Results for Subject 1 are explained in detail below and illustrated in Figure 1.

Baseline. Four baseline measures were collected for Subject 1. Subject 1 incorrectly selected one symbol during the first baseline measure. No incorrect or correct selections were made during the second baseline measure. During the third baseline measure, Subject 1 incorrectly selected nine symbols. Subject 1 incorrectly selected five symbols during the fourth baseline measure and correctly selected one symbol. However, this symbol was not from the initial target vocabulary set (i.e., teaching vocabulary set); thus, during the baseline phase, Subject 1 never correctly selected a target symbol from the teaching set of vocabulary.

Phase 1. Each weekly probe during Phase 1 consisted of 24 total elicited opportunities to select a target symbol. During the first weekly probe, Subject 1 correctly selected one symbol and incorrectly selected twelve symbols. The second weekly probe consisted of only twelve incorrect symbol selections. During the third weekly probe, Subject 1 had no correct selections but thirteen incorrect selections. The final weekly probe showed Subject 1 correctly selected three symbols and incorrectly selected thirteen symbols. Overall, weekly probes collected during Phase 1 revealed a slight but inconsistent increase in the number of correct selections, ranging from zero to three. Incorrect selections were consistent during Phase 1, ranging from twelve to thirteen. However, weekly probes demonstrated an overall increase in the number of selections (i.e., incorrect and correct selections) from the baseline measures ranging from one to nine total selections per measure to twelve to sixteen total selections per probe during Phase 1.

Maintenance-phase 1 withdrawal. During the first maintenance probe collected during Phase 1 withdrawal, Subject 1 correctly selected two symbols and incorrectly selected an additional fourteen symbols. Subject 1 again correctly selected two symbols during the second maintenance probe of Phase 1 withdrawal and incorrectly selected an additional five symbols. Correct symbol selection was consistent during these maintenance phases; however, a decrease of nine was noted in total number of selections from the first maintenance probe to the second.

Phase 2. The first weekly probe collected during Phase 2 revealed Subject 1 correctly selected four symbols and incorrectly selected an additional fifteen symbols. The second weekly probe showed no correct selections but a total of 21 incorrect selections. No correct selections were made during the third weekly probe, and incorrect selections decreased to ten. During the final weekly probe, Subject 1 correctly selected one symbol and incorrectly selected an additional sixteen symbols. Overall, correct symbol selection varied from zero to four during weekly probes in Phase 2. However, an overall increase in the total number of selections was seen again from the Phase 1 to Phase 2 with the exception of one day.

Maintenance-phase 2 withdrawal. Subject 1 correctly selected one symbol during the first maintenance probe during Phase 2 withdrawal with an additional three symbols incorrectly selected. The second maintenance probe revealed that Subject 1 correctly selected one target symbol and did not incorrectly select any additional symbols. Maintenance probes collected following Phase 2 demonstrated one correct selection for both probes but a decrease in the total number of symbol selections from the first probe to the second probe.

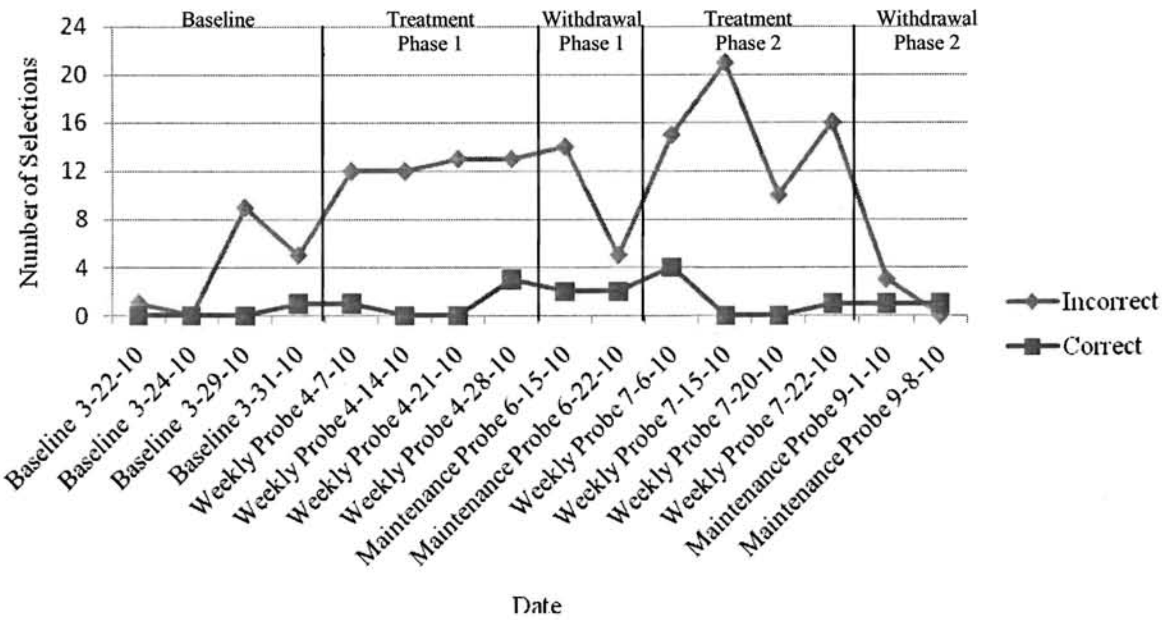

Figure 1. Subject 1's symbol acquisition of positional concepts

Generalization. Generalization probes are detailed below and illustrated in Figure 2.

Phase 1 withdrawal. The initial generalization probe collected during Phase 1 withdrawal revealed that Subject 1 correctly selected three symbols and incorrectly selected an additional nine. Subject 1 correctly selected two symbols during the second generalization probe with an additional ten incorrect selections. During the final generalization probe collected during Phase 1 withdrawal, Subject 1 correctly selected one symbol and incorrectly selected an additional six symbols. Over time, Subject 1 showed a decrease in the number of correct selections made as generalization probes were collected farther from the last sessions in Phase 1. The total number of selections for generalizations probes in the Phase 1 withdrawal showed a decrease in the total selections for the last probe collected.

Phase 2 withdrawal. Subject 1 correctly selected two symbols during the first generalization probe collected during Phase 2 withdrawal with an additional selection of fourteen incorrect symbols. During the second generalization probe, Subject 1 correctly selected one symbol and incorrectly selected three symbols. A total of one correct selection and nine incorrect selections were made by Subject 1 during the final generalization probe. Correct symbol selection showed a slight decrease as generalization probes were collected farther from the last sessions in Phase 2. Total symbol selection was variable for the generalization probes collected during this withdrawal period.

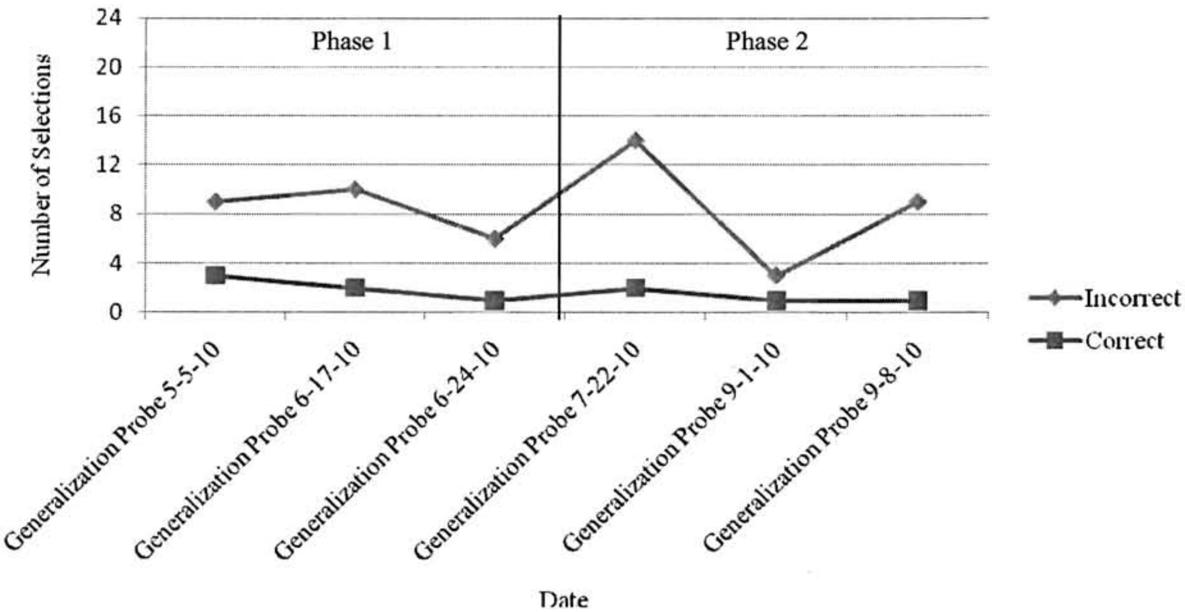

Figure 2. Subject 1's generalization of positional concepts

Cuing and assistance. As previously stated, the final dependent variable in this study measured the amount of cuing required during the errorless learning teaching sessions in Phase 1 and Phase 2. Data were collected on each learning opportunity provided to determine which level of the cuing hierarchy (i.e., general cue, specific cue, hand-over-hand) the subject required. A total of sixteen learning opportunities were presented during each errorless learning teaching session for Subject 1.

Phase 1. Table 3 details the number of selections achieved at each of the four levels of the cuing hierarchy. As previously stated, a total of sixteen opportunities were presented to Subject 1 during each errorless learning teaching session. However, disruptive or negative behaviors affected data collection on several dates, and thus, only the learning opportunities presented were recorded. The number of selections achieved at each level of the cuing hierarchy varied daily. Overall results for Subject 1 revealed that as Phase 1 progressed, the number of independent selections and selections when only a general cue was provided increased.

Table 3

Subject 1's Phase 1 Cuing Data

Date	Independent	General Cue	Specific Cue	Hand-over-hand
*4/5/2010	4	2	0	0
*4/7/2010	6	4	1	0
4/12/2010	5	3	7	1
*4/14/2010	1	3	0	1
4/19/2010	6	5	5	0
*4/21/2010	2	5	1	2
4/26/2010	10	2	3	1
4/28/2010	12	3	1	0

*Sessions could not be completed due to disruptive behaviors.

Phase 2. Data regarding the number of selections achieved at each level of the cuing hierarchy during Phase 2 are displayed in Table 4. The number of selections achieved at each level again varied daily. Subject 1 showed an overall increase in the number of independent selections during Phase 2 from Phase 1 as illustrated in Figure 3.

General cues remained the most prevalent type of cue required; however, specific cues were used more consistently during Phase 2.

Table 4

Subject 1's Phase 2 Cuing Data

Date	Independent	General Cue	Specific Cue	Hand-over-hand
6/29/10	12	3	1	0
7/6/2010	3	7	4	2
7/8/2010	5	7	4	0
7/13/2010	8	4	3	1
7/15/2010	12	2	2	0
7/20/2010 (A)	13	1	2	0
7/20/2010 (B)	8	5	1	2
7/22/2010	11	4	1	0

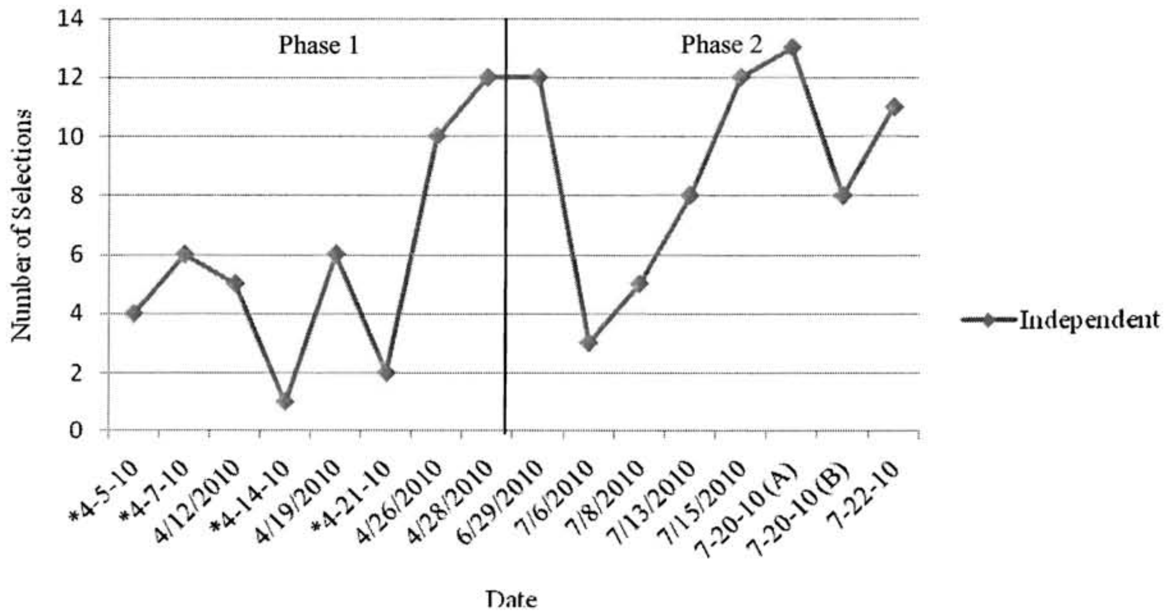

Figure 3. Subject 1's independent selections across phases 1 and 2. Sessions marked with an asterisk (*) could not be completed due to disruptive behaviors.

Subject 2.

Acquisition. Data regarding symbol acquisition of Subject 2 were collected using the same procedures as Subject 1. Results are illustrated in Figure 4 and detailed below.

Baseline. Three baseline measures were collected for Subject 2. During all baseline measures, Subject 2 selected no symbols.

Phase 1. Due to disruptive/negative behaviors from Subject 2 during the initial weekly probe, only two opportunities were provided. Subject 2 did not select symbols at either opportunity. During the second weekly probe, Subject 2 correctly selected three symbols and incorrectly selected an additional fifteen symbols. The third weekly probe revealed an accurate symbol selection of two symbols with an additional twelve incorrect selections. Subject 2 correctly selected one symbol during the final weekly probe in Phase 1 and incorrectly selected an additional fifteen. Subject 2 demonstrated a slight decrease in total selections (i.e., correct and incorrect selections) and in total correct selections during weekly probes as Phase 1 progressed.

Maintenance-phase 1 withdrawal. The initial maintenance probe collected during Phase 1 withdrawal revealed that Subject 2 incorrectly selected seven symbols; no correct selections were elicited. During the second maintenance probe in the Phase 1 withdrawal, Subject 2 incorrectly selected four symbols and, again, had zero correct selections. Maintenance probes revealed a decrease in total symbol selection and in total correct symbol selection from Phase 1.

Phase 2. Subject 2 correctly selected two symbols during the initial weekly probe collected during Phase 2; an additional thirteen incorrect selections were also exhibited. During the second weekly probe, Subject 2 correctly selected three symbols and incorrectly selected an additional nineteen. The third weekly probe revealed an accurate selection of two symbols and an incorrect selection of eighteen symbols. During the final weekly probe, Subject 2 correctly selected three symbols and incorrectly selected an additional eighteen symbols. Subject 2 again showed an increase in total symbol selection, with the exception of the first weekly probe, from Phase 1 to Phase 2. Total symbol selection for the first probe was consistent with selections from Phase 1. The number of correct selections from Subject 2 was more consistent during Phase 2 as well.

Maintenance-phase 2 withdrawal. Due to disruptive behaviors from Subject 2, the initial maintenance probe during Phase 2 withdrawal was unable to be collected. During the second maintenance probe, Subject 2 correctly selected two symbols. No incorrect selections were exhibited. The total of correct selections during this maintenance probe was consistent with the totals for the weekly probes during Phase 2; however, the total number of selections (i.e., correct and incorrect selections) decreased.

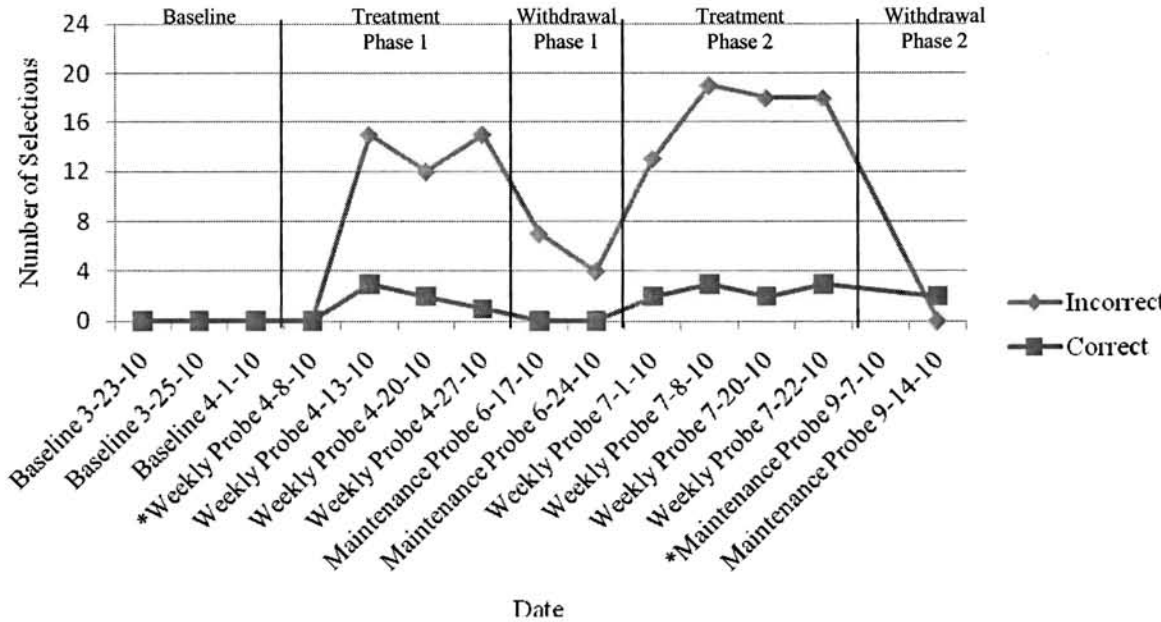

Figure 4. Subject 2's symbol acquisition of positional concepts. Probes marked with an asterisk (*) could not be completed due to disruptive behaviors.

Generalization. Procedures for generalization probes were identical for Subjects 1 and 2. Generalization results are detailed below for Subject 2 and illustrated in Figure 5.

Phase 1 withdrawal. During the initial generalization probe during Phase 1 withdrawal, Subject 2 did not select any symbols. During the second generalization probe, Subject 2 incorrectly selected three symbols but did not correctly select any additional symbols. No correct selections and only one incorrect selection were observed during the final generalization probe. Overall results for Subject 2's generalization probes during Phase 1 withdrawal showed zero correct selections and inconsistent numbers of incorrect selections.

Phase 2 withdrawal. The initial generalization probe collected during Phase 2 withdrawal revealed that Subject 2 accurately selected two symbols during the joint book reading activity and incorrectly selected an additional sixteen symbols. Due to disruptive behaviors, no generalization probe could be collected on for the second probe, and only a partial probe could be collected on for the final probe. A total of thirteen opportunities were elicited during the partial generalization probe; Subject 2 did not select a symbol for any of these opportunities. Overall, the initial generalization probe elicited a total number of correct responses consistent with weekly probes and maintenance probes for Phase 2.

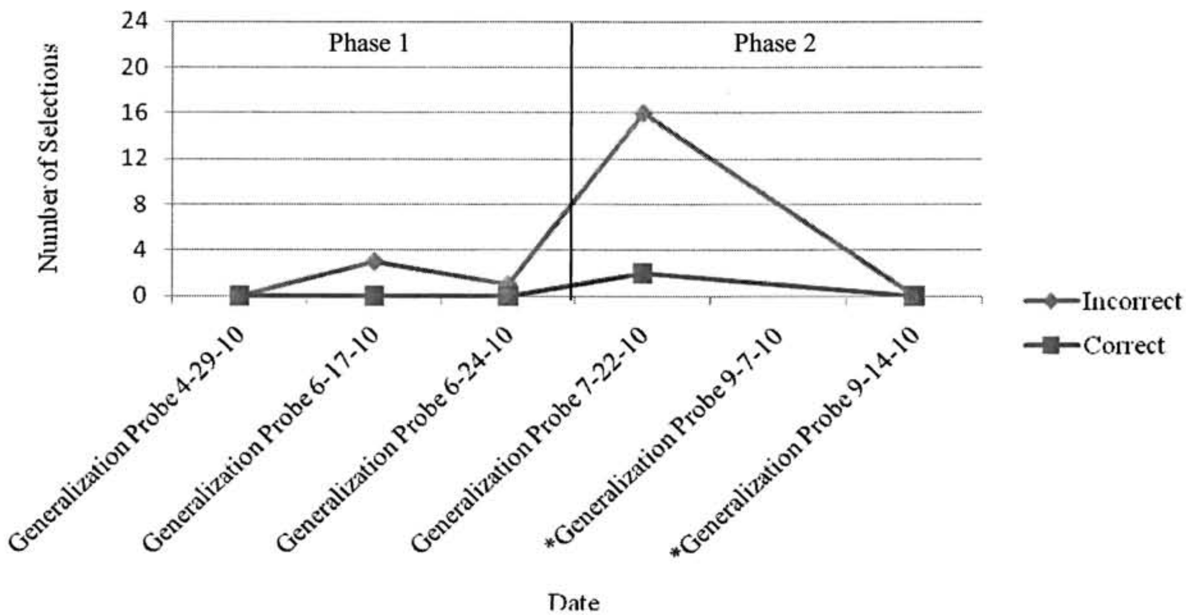

Figure 5. Subject 2's generalization of positional concepts. Probes marked with an asterisk (*) could not be completed due to disruptive behaviors.

Cuing and assistance. The same cuing hierarchy as was used for Subject 1 was used for Subject 2 to collect data on the amount of assistance required for each learning opportunity presented during the errorless learning teaching sessions. Results are detailed below.

Phase 1. Table 5 displays the number of selections provided at each level of the cuing hierarchy. Due to disruptive/negative behaviors from Subject 2, errorless learning teaching sessions were affected on several dates during Phase 1. For those dates, only the learning opportunities presented were recorded. The number of selections achieved at each level varied daily; however, as Phase 1 progressed, Subject 2 showed a decrease in the need for hand-over-hand assistance from eight selections in the first session to three selections in the last session. Similarly, a decrease was seen in the number of specific cues required, from four in the initial session to one in the final session. The number of independent selections and selections from general cues were variable throughout Phase 1, but they were the most common response on two separate days when disruptive behaviors did not affect data collection.

Table 5

Subject 2's Phase 1 Cuing Data

Date	Independent	General Cue	Specific Cue	Hand-over-hand
4/6/2010	3	1	4	8
4/8/2010	5	2	3	6
*4/13/2010	3	3	0	1
4/15/2010	8	2	2	4
*4/20/2010	0	0	1	11
4/22/2010	3	1	4	8
*4/27/2010	1	1	0	6
4/29/2010	5	7	1	3

*Sessions could not be completed due to disruptive behaviors.

Phase 2. Table 6 displays the distribution of the number of selections for each level of the cuing hierarchy during each errorless learning teaching session. Disruptive/negative behaviors impacted complete administration of all learning opportunities during the first errorless learning teaching session in Phase 2, but no other sessions were affected during Phase 2. During Phase 2, Subject 2's need for hand-over-hand assistance was completely eliminated during the last two teaching sessions. The need for specific cues also decreased across Phase 2. In contrast, the number of selections resulting from a general cue and the number of independent selections increased throughout Phase 2. Figure 6 illustrates Subject 2's increase in independent responses across both treatment phases.

Table 6

Subject 2's Phase 2 Cuing Data

Date	Independent	General Cue	Specific Cue	Hand-over-hand
*6/29/2010	1	0	0	2
7/1/2010	2	2	2	10
7/6/2010	6	2	4	4
7/8/2010	10	4	1	1
7/15/2010	6	6	2	2
7/20/2010 (A)	9	3	2	2
7/20/2010 (B)	13	3	0	0
7/22/2010	10	5	1	0

*Sessions could not be completed due to disruptive behaviors.

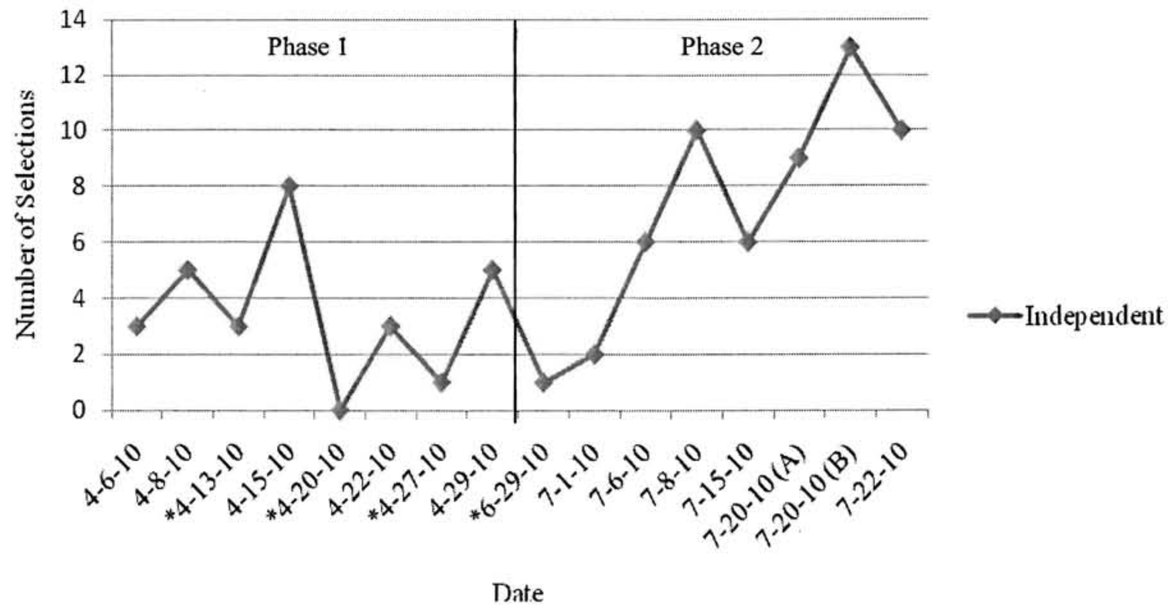

Figure 6. Subject 2's independent selections across phases 1 and 2. Sessions marked with an asterisk (*) could not be completed due to disruptive behaviors.

Acquisition of Comments

The process used to measure the acquisition of comments was similar to the process used to measure the acquisition of concepts with the following exceptions: 1) the number of target vocabulary taught during Phases 1 and 2 increased to ten, 2) the total number of response opportunities for each weekly, maintenance, and generalization probes increased to 30, and 3) weekly probes and maintenance probes were collected during joint book reading activities while generalization probes were collected during play-based activities. Results for Subjects 3 and 4 are discussed in further detail below.

Subject 3.

Acquisition. Results regarding Subject 3's acquisition of comments are detailed below and are displayed in Figure 7.

Baseline. A total of three baseline measures were collected for Subject 3. For all baseline measures, Subject 3 selected zero symbols.

Phase 1. During the first weekly probe, Subject 3 did not correctly select any target symbols and incorrectly selected one symbol. During the second weekly probe, Subject 3 did not select any symbols. However, during the final weekly probe, Subject 3 correctly selected three target symbols and incorrectly selected an additional 23 symbols. Overall, Subject 3's total number of selections (i.e., correct and incorrect selections) and the total number of correct selections increased significantly during the last weekly probe.

Maintenance-phase 1 withdrawal. For both maintenance probes collected following Phase 1, Subject 3 incorrectly selected one target symbol and did not correctly select any target symbols. Total symbol selection (i.e., correct and incorrect selections) and correct symbol selection decreased from the weekly probes collected during Phase 1 to these maintenance probes.

Phase 2. At the beginning of Phase 2, Subject 3 moved along the graded choice continuum during the errorless learning teaching sessions for two symbols. For the initial weekly probe, Subject 3 did not correctly select any symbols and incorrectly selected two symbols. During the second weekly probe, Subject 3 again selected zero correct symbols but incorrectly selected four symbols. Subject 3 correctly selected two symbols during the third probe with an additional ten incorrect selections. During the final weekly probe in Phase 2, Subject 3 made no correct selections but incorrectly selected eleven symbols. Subject 3 showed an overall increase in total symbol selections (i.e., correct and incorrect selections) as weekly probes progressed. An increase in correct selections occurred only during the third weekly probe.

Maintenance-phase 2 withdrawal. Due to behaviors and time limitations, the initial maintenance probe could not be completely administered. Of the 22 opportunities presented, Subject 3 made no correct selections and made three incorrect selections. During the second maintenance probe, Subject 3 correctly selected one symbol and incorrectly selected an additional six. Both total selections and correct selections increased during the final maintenance probe but were a slight decrease from results of weekly probes during Phase 2.

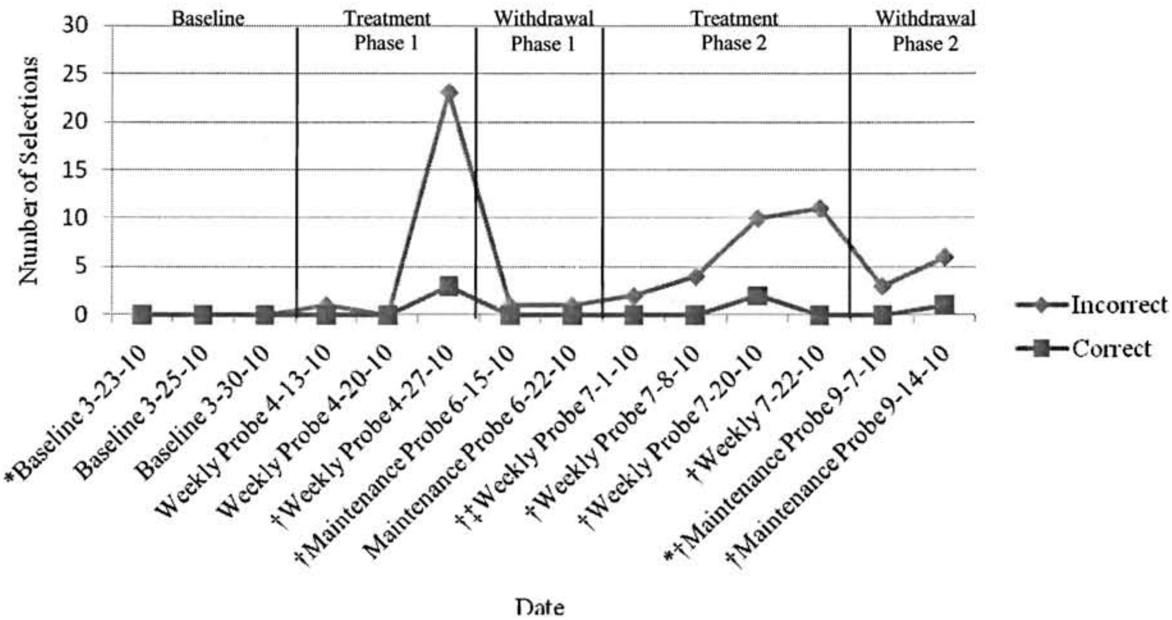

Figure 7. Subject 3's symbol acquisition of comments. Probes marked with an asterisk (*) could not be completed due to disruptive behaviors; those designated with a cross (†) mark dates on which additional appropriate comments were made. Dates marked with a double cross (‡) designate days where Subject 3 moved along the errorless learning graded choice continuum.

Generalization. Generalization results for Subject 3 are detailed below and illustrated in Figure 8.

Phase 1 withdrawal. Subject 3 correctly selected one symbol during the initial generalization probe in Phase 1 withdrawal and incorrectly selected an additional eleven symbols. During the second generalization probe, Subject 3 again correctly selected one symbol and incorrectly selected nine additional symbols. During the final generalization probe, Subject 3 did not select any symbols. Throughout the generalization probes in Phase 1 withdrawal, Subject 3's total number of selections decreased as probes were collected farther from the end of Phase 1. Her total correct selections for the first two generalization probes decreased from the final weekly probe in Phase 1.

Phase 2 withdrawal. Subject 3 incorrectly selected two symbols during the initial generalization probe collected during Phase 2 withdrawal. Due to behaviors and time limitations, the entire second generalization probe could not be administered. Of the sixteen opportunities completed, Subject 3 did not make any correct selections but incorrectly selected one symbol. A total of nine incorrect selections were revealed during the final generalization probe with no additional correct selections. Subject 3 demonstrated no variation in the number of correct selections per probe but the total number of selections increased during the final probe of Phase 2 withdrawal.

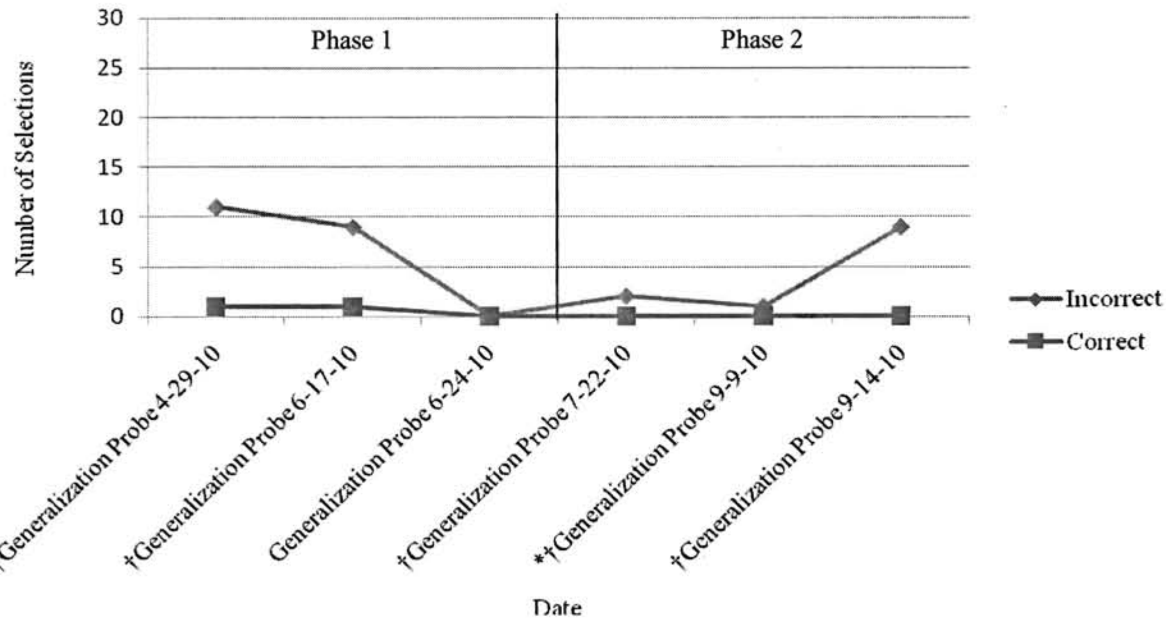

Figure 8. Subject 3's generalization of comments. Probes marked with an asterisk (*) could not be completed due to disruptive behaviors. Probes marked with a cross (†) designate dates on which additional appropriate comments were made.

Cuing and assistance. The cuing hierarchy used during the errorless learning teaching sessions for Subject 3 was the same one used for Subjects 1 and 2. Detailed results of the amount of assistance Subject 3 required during teaching sessions are detailed below.

Phase l. Table 7 details the number of selections Subject 3 provided at each level of the cuing hierarchy during Phase 1 errorless learning teaching sessions. The number of selections elicited using hand-over-hand assistance decreased from twelve during the initial teaching session to zero in the final session. The number of selections elicited at the level of specific cues remained fairly consistent at three responses per day with slight variations on several dates. The number of Subject 3's independent selections increased from four in the initial phase to fifteen during the last session. During the final session of

Phase 1, Subject 3's independent selection increased sufficiently for her to move along the errorless learning graded choice continuum, indicating mastery of two symbols at the lowest level of the continuum (i.e., only the correct choice available for selection).

Table 7

Subject 3's Phase 1 Cuing Data

Date	Independent	General Cue	Specific Cue	Hand-over-hand
4/8/2010	4	0	3	12
4/13/2010	13	2	1	4
4/15/2010	9	5	5	1
4/20/2010	7	5	4	4
4/22/2010	9	5	3	3
4/27/2010	12	5	2	1
4/29/2010	15	2	3	0

Phase 2. Table 8 details the number of selections Subject 3 provided at each level of the cuing hierarchy. During the initial errorless learning teaching session in Phase 2, the amount of cuing again increased (i.e., the number of independent responses decreased from the final session in Phase 1). As Phase 2 progressed the amount of cuing decreased to a similar level as was required at the end of Phase 1. Independent selections increased from two during the initial session to thirteen and eight during the final two sessions. During Phase 2, Subject 3 did not move along the graded choice continuum for any other symbols. Figure 9 illustrates Subject 3's number of independent responses across both Phase 1 and Phase 2.

Table 8

Subject 3's Phase 2 Cuing Data

Date	Independent	General Cue	Specific Cue	Hand-over-hand
6/29/2010	2	1	12	5
7/1/2010	6	5	6	3
7/6/2010	4	7	8	1
7/8/2010	13	1	1	5
7/12/2010	7	3	7	3
7/13/2010	8	8	4	0
7/20/2010	13	3	4	0
7/22/2010	8	4	6	2

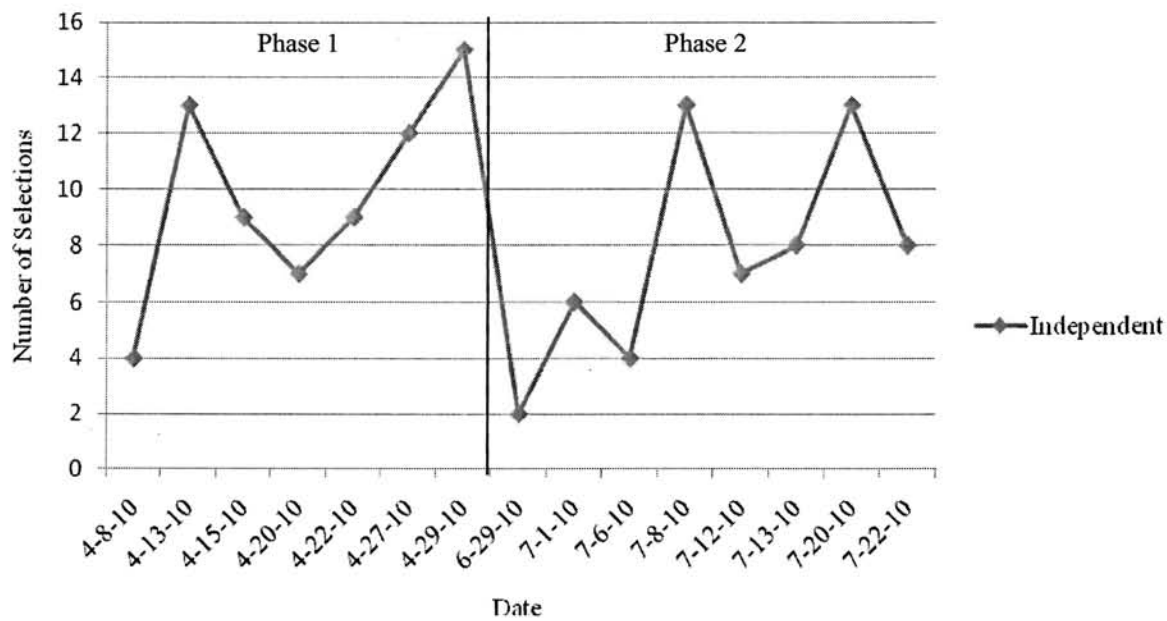

Figure 9. Subject 3's independent selections across phases 1 and 2

Subject 4.

Acquisition. The same procedures used for measuring symbol acquisition for Subject 3 were employed to measure Subject 4's progress. Results for Subject 4 are detailed below and displayed in Figure 10.

Baseline. The initial baseline measure could not be completed due to disruptive behaviors from Subject 4. The remaining baseline measures revealed that Subject 4 never selected any symbols.

Phase 1. Due to disruptive/negative behaviors, no complete weekly probes could be administered during Phase 1. A partial probe was completed during the second weekly probe; Subject 4 incorrectly selected one symbol from the five opportunities presented to her and did not correctly select any symbols.

Maintenance-phase 1 withdrawal. Two maintenance probes were collected during Phase 1 withdrawal for Subject 4. During those two probes, Subject 4 selected zero symbols. However, both probes were able to be completely administered with no disruptive/negative behaviors.

Phase 2. During the initial weekly probe, Subject 4 correctly selected three symbols and incorrectly selected an additional fifteen. Prior to the second weekly probe, Subject 3 moved along the graded choice continuum for one symbol during the errorless learning teaching sessions. During the second probe, Subject 4 correctly selected two symbols and incorrectly selected an additional ten. Again, prior to the third weekly probe, Subject 3 moved along the graded choice continuum for a second symbol during the errorless learning teaching session. Three correct selections were elicited during the third weekly probe with an additional 22 incorrect selections. During the final weekly probe, Subject 4 correctly selected two symbols and incorrectly selected an additional seventeen symbols. Overall, Subject 4's total number of selections and number of correct selections increased from previous probes during Phase 2.

Maintenance-phase 2 withdrawal. The first maintenance probe collected following Phase 2 revealed a correct symbol selection of two and an incorrect symbol selection of three. During the second maintenance probe, Subject 4 correctly selected two symbols and incorrectly selected an additional seven symbols. Subject 4's number of correct selections during these maintenance probes was consistent with the weekly probes from Phase 2; however, the total number of selections per probe decreased.

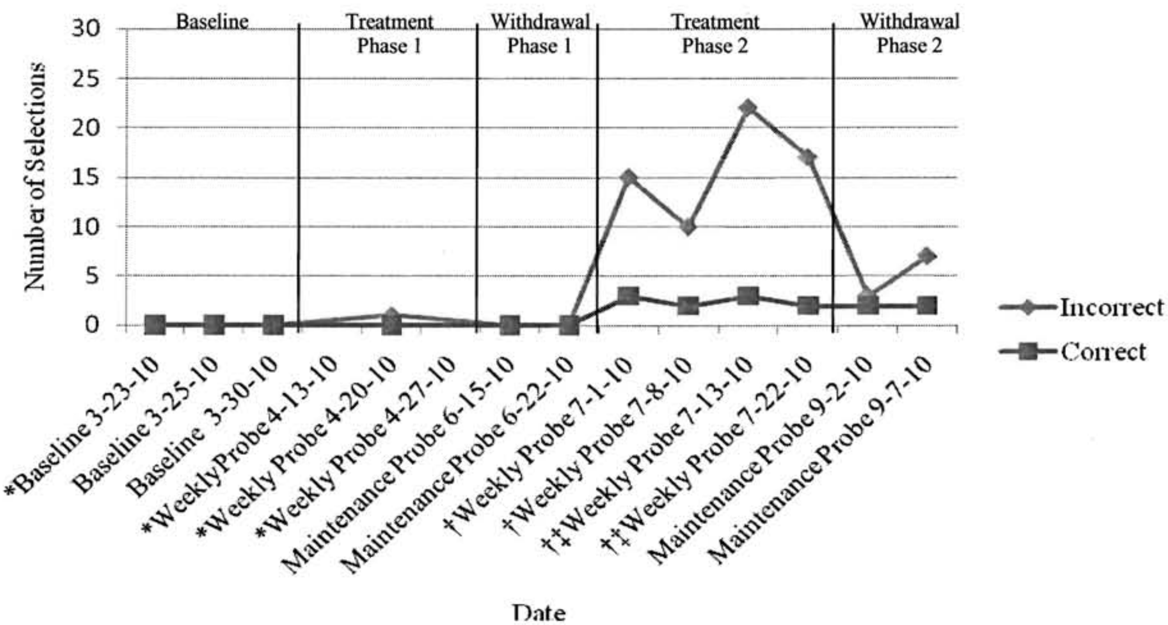

Figure 10. Subject 4's symbol acquisition of comments. Probes marked with an asterisk (*) could not be completed due to disruptive behaviors; those marked with a cross (†) designate dates on which additional appropriate comments were made. Dates marked with a double cross (‡) mark dates that Subject 4 moved along the errorless learning graded choice continuum.

Generalization. Results of generalization probes for Subject 4 are detailed below and illustrated in Figure 11.

Phase 1 withdrawal. Three generalization probes were collected for Subject 4 during Phase 1 withdrawal. During the initial generalization probe, Subject 4 correctly selected two symbols and incorrectly selected an additional sixteen symbols. During the second and third generalization probes, Subject 4 did not select any symbols. Thus, Subject 4 showed a decrease in the total number of selections and the number of correct selections during the generalization probes farthest from the end of Phase 1.

Phase 2 withdrawal. Subject 4 correctly selected zero symbols during the initial generalization probes and incorrectly selected one symbol. Due to disruptive behaviors the second generalization probe could not be completely administered. Of the 21 opportunities presented, Subject 4 correctly selected one symbol and incorrectly selected an additional two symbols. During the final generalization probe, Subject 4 incorrectly selected only one symbol. Overall, the total number of selections and the number of correct selections decreased during the generalization probes in Phase 2 withdrawal from the probes collected during Phase 2.

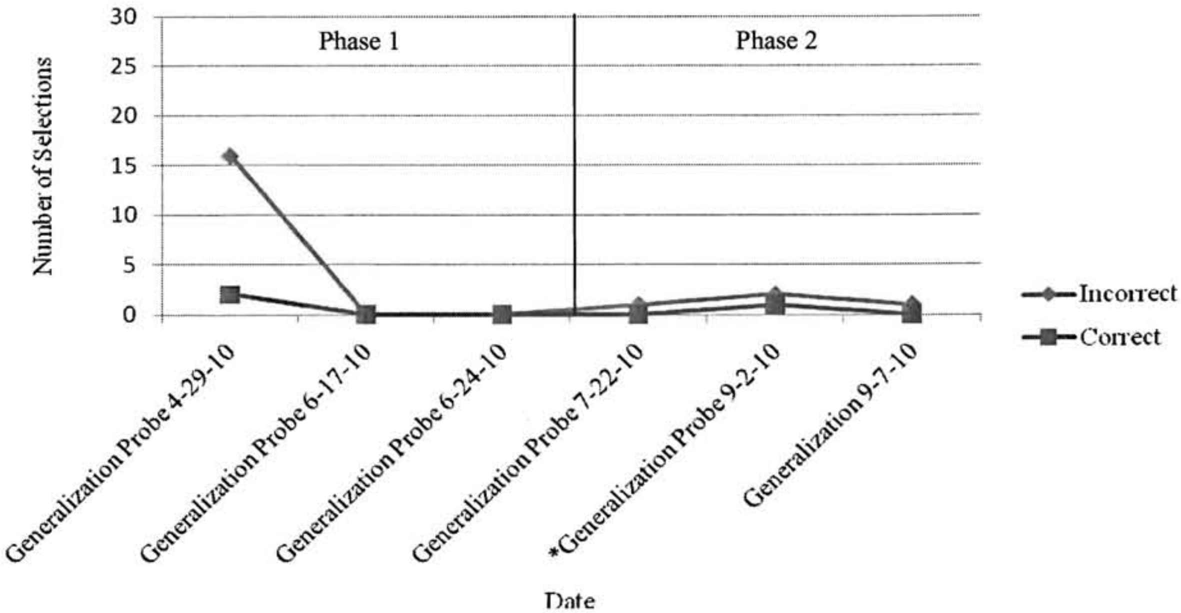

Figure 11. Subject 4's generalization of comments. Probes marked with an asterisk (*) could not be completed due to disruptive behaviors.

Cuing and assistance. The amount of assistance required by Subject 4 is detailed below according to each treatment phase.

Phase 1. Table 9 details the number of selections elicited for each level of the cuing hierarchy from Subject 4 during Phase 1. Subject 4's results revealed that hand-over-hand assistance was required during the first three errorless learning teaching sessions for three to four selections; however, no hand-over-hand was required for the remainder of teaching sessions in Phase 1. The number of selections with the use of general cues remained at twelve for the initial session and the final sessions; however, variability was seen on several dates throughout Phase 1. Independent selections were inconsistent across the course of Phase 1. Independent selections showed a significant increase during the second teaching session from zero to twelve. This increase was followed by a marked decrease to four selections. However, following this initial decrease, independent selections steadily increased over the remainder of Phase 1 to eight selections with a decrease to three selections noted during the final teaching session.

Table 9

Subject 4's Phase 1 Cuing Data

Date	Independent	General Cue	Specific Cue	Hand-over-hand
4/8/2010	0	12	5	3
4/13/2010	12	5	0	3
4/15/2010	4	5	7	4
4/20/2010	3	11	6	0
4/22/2010	5	12	3	0
*4/27/2010	8	3	0	0
4/29/2010	3	12	5	0

*Sessions could not be completed due to disruptive behaviors.

Phase 2. The number of selections for Subject 4 is displayed in Table 10 below. During Phase 2, Subject 4 continued to require hand-over-hand assistance occasionally for one or two selections, but this was the least required form of cuing. Specific cues decreased over the course of Phase 2 and were minimally used for the last four teaching sessions of Phase 2 for only one selection. General cues were again the most common type of cue required by Subject 4 ranging from one to six selections per session. Independent selections remained fairly consistent across Phase 2, ranging from thirteen to eighteen with the exception of two dates where independent selections dropped to seven and ten. Subject 4 moved along the graded choice continuum for two symbols during Phase 2. The first symbol was moved along the continuum on July 13, 2010 and the second symbol was moved along the continuum on July 20, 2010. During the last teaching session in Phase 2, Subject 4 independently and accurately selected the target symbol (versus the foil symbol) at all opportunities for both symbols for which she moved along the graded choice continuum. Figure 12 illustrates the independent selections made by Subject 4 across both treatment phases.

Table 10

Subject 4's Phase 2 Cuing Data

Date	Independent	General Cue	Specific Cue	Hand-over-hand
6/29/2010	17	3	0	0
7/1/2010	13	4	3	0
7/6/2010	7	4	8	1
7/8/2010	10	6	2	2
7/12/2010	17	1	1	1
7/13/2010	11	6	1	2
7/20/2010	16	3	1	0
7/22/2010	18	1	1	0

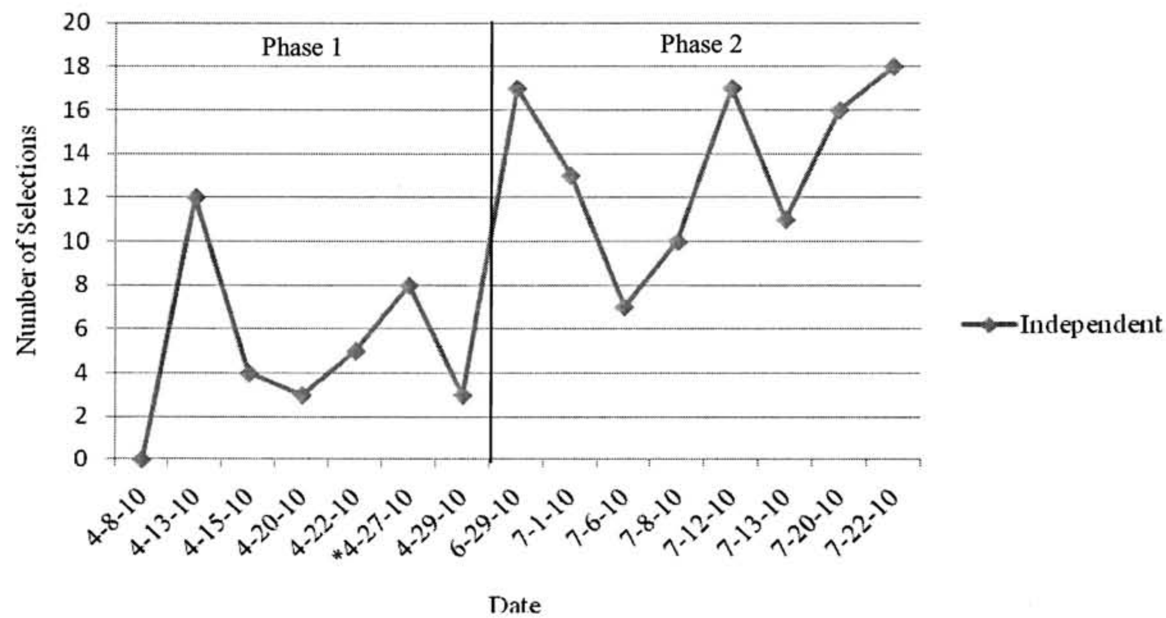

Figure 12. Subject 4's independent selections across phases 1 and 2. Probes marked with an asterisk (*) could not be completed due to disruptive behaviors.

Chapter V

Discussion

This study primarily sought to determine the effectiveness of errorless learning for teaching linguistic skills, specifically symbol acquisition, to children with autism who used an augmentative and alternative communication system. The children were taught functional vocabulary (i.e., vocabulary other than nouns) in the form of either concepts or comments through a graded choice errorless learning format. Secondarily, this study examined whether errorless learning was more effective for improving symbol acquisition of concepts or comments in children with autism. Thus, two subjects were chosen to learn concepts and two subjects were chosen to learn comments.

Results from this study can neither validate nor discredit errorless learning as an appropriate teaching strategy for children with autism who use an AAC device as their primary means of communication. Results of the study were variable between subjects and within individual subjects; thus, no clear pattern of symbol acquisition emerged. However, several common themes were noted during errorless learning teaching sessions and across weekly, maintenance and generalization probes for all subjects. These themes are discussed in further detail below in relation to the two research questions posed during this study:

1) To what extent do children with autism improve symbol acquisition skills when instructed using an errorless learning strategy?

    a. Is errorless learning effective for improving symbol acquisition (i.e., correct symbol selections) and/or communicative attempts (i.e., total symbol responses, correct and incorrect) within an activity similar to the teaching context?

b. Is errorless learning effective for improving symbol acquisition and/or communicative attempts within a new context/activity?

c. Is errorless learning effective for improving initiation and independence of responses for newly acquired symbols?

2) Is an errorless learning teaching strategy more effective for improving symbol acquisition of concepts or comments in children with autism?

Symbol Acquisition

Weekly and maintenance probes. Subjects showed limited success across all weekly and maintenance probes. This may be the result of several factors. It may be attributed to disruptive behaviors (e.g., kicking, screaming, pinching, hitting) and inattentiveness to tasks (e.g., flicking the AAC device, walking away from clinician) observed throughout the course of this study. These disruptive behaviors were most likely due to a change in routine as a result of the introduction of new activities and unfamiliar clinicians involved with the research study. Research has shown that many children with autism have increased anxiety and behavioral outbursts as a result of a change in the order of their routine (ASHA, 2006; Ogletree & Oren, 1998; Richard, 1997). A lack of understanding of activity expectations (i.e., what was required of them during the study) may also explain some of the disruptive behaviors and inattentiveness exhibited by the subjects. The fact that fewer sessions were interrupted due to disruptive behaviors during the second teaching phase suggested that as the activities introduced during the study became better incorporated into their normal routine and as subjects better understood what was expected of them during tasks, they were less anxious and more likely to participate.

Other factors which may have attributed to the limited success with symbol acquisition are related to the design of the research study. This study examined symbol acquisition with low intensity therapy (i.e., approximately two hours of intervention for each treatment phase). Better symbol acquisition may have resulted from more intense treatment. The number of symbols chosen for instruction may have been too high for the current cognitive levels of subjects as well, or the number of symbols being taught may have been too many to teach simultaneously given the low intensity level of treatment. Symbols taught in this study represented more abstract concepts than standard nouns and may have hindered symbol acquisition as well. The teaching contexts may also have been too abstract to achieve a high level of symbol acquisition. Better acquisition may have been achieved by using more concrete vocabulary or by relating the vocabulary chosen to individual subjects rather than to books and objects. The poor symbol acquisition seen in this study may also be the result of the errorless learning teaching strategy itself. By presenting only the correct response at one time, subjects were not required to actively discriminate between symbols to determine the accuracy of a response. This low level of cognitive engagement may have improved the subjects' understanding of when a response was required but hindered true learning of the symbols.

Factors within individual subjects may also have resulted in the limited symbol acquisition obtained in this research study. Subjects may have lacked the cognitive skills necessary to effectively acquire new symbols in such a limited amount of time. Subjects may also have lacked motivation in relation to the activities chosen as learning contexts for this study which may have negatively impacted learning of new symbols.

Although no clear pattern of symbol acquisition emerged, one common theme observed among all subjects over the course of the study was an overall increase in the total number of symbol selections, both correct and incorrect. This may again suggest that the subjects did not completely understand the expectations at the start of the study. However, as the study progressed, subjects better understood their role in the interaction (i.e., that a response was required) even if all target vocabulary were not correctly learned. The concepts being taught may also have been too abstract or cognitively high for the subjects in this study. It may also suggest that errorless learning is effective for improving initiation and independence of responses but is not effective for teaching quick, accurate symbol acquisition.

Within this theme of overall increases in total symbol selections, there were several inconsistencies between subjects. One such inconsistency was the nature of the correct symbol selection among subjects (see Appendix G for raw data regarding the distribution of correct selections across symbols). Subjects 1 and 3 both showed variability in the number of correct responses and in the symbols which were correctly selected from day-to-day. This suggested a random selection pattern rather than true learning of the symbols. In contrast, Subjects 2 and 4 demonstrated more consistent numbers of correct symbol selection during Phase 2; however, this was most likely due to a perseveration of responses rather than an increased learning of the symbols. Most of the correct symbol selections were primarily the result of a repeated selection of one symbol from the foil vocabulary set rather than selections demonstrating any learning of symbols from the teaching vocabulary set. Previous research has shown that perseveration is often observed in children with autism (ASHA, 2006; Richard, 1997). Although responses appeared random in the case of Subjects 1 and 3 and perseverative in the case of Subjects 2 and 4, the overall increase in the total number of selected symbols suggested that the subjects better understood when a response was required as the study progressed. These results are similar to results achieved by Colgan (2009) which examined aided language modeling for teaching functional communication (e.g., commenting and responding to questions) to children with autism who used an AAC system. Colgan found increases in functional vocabulary for the subjects within her study, but these increases were variable across subjects.

It was also observed that Subjects 3 and 4 selected alternative, appropriate comments throughout Phases 1 and 2 during weekly and maintenance probes. However, for most of these comments, the symbols selected were again from the foil vocabulary set versus the teaching vocabulary set. For example, during the last weekly probe in Phase 1, Subject 3 selected an additional 33 appropriate comments, all of which were the non-taught target symbol, *Look*. Similarly, during Phase 2, Subject 4 repeatedly selected the non-taught symbol, *I like* from the foil vocabulary set. One possible explanation for the use of these symbols would be prior exposure and inadvertent modeling. Although these symbols were not taught using an errorless learning teaching strategy during Phase 1 or Phase 2, multiple verbal models were provided during natural interactions with the book and may also have been provided during natural interactions throughout their school day, within their home environment or during other speech therapy. These verbal models may account for the subjects' use of these symbols. The presence of these additional comments could also indicate that Subjects 3 and 4 acquired a better understanding of the nature of commenting rather than learning specific target symbols. Another explanation is that the symbol selections were a perseverative response, which, as previously stated, is common among children with autism (ASHA, 2006; Richard, 1997), as Subjects 3 and 4 selected the same symbols multiple times during the activity.

Graded choice continuum. Although no significant pattern of symbol acquisition was observed across the study, progress for two subjects on the graded choice continuum used during errorless learning teaching sessions provided additional information about potential for learning. Subjects 1 and 2 showed no consistent pattern of learning during errorless learning teaching sessions and, thus, did not move along the graded choice continuum. In contrast, both Subjects 3 and 4 moved along the graded choice continuum for two symbols. The ability to move along the graded choice continuum showed a level of mastery over the symbols as demonstrated by independent and consistent accurate selection of symbols over consecutive sessions. Subject 3 moved along the graded choice continuum for two symbols during the first errorless learning teaching session in Phase 2, while Subject 4 moved along the continuum for one symbol during the sixth teaching session in Phase 2 and for another symbol during the eighth teaching session in Phase 2. These results were consistent with the results achieved by Storm and Robinson (1973) which demonstrated that errorless learning with a graded choice format was an effective intervention technique.

Generalization. Minimal generalization was seen for all subjects during this study. These generalization results are consistent with previous research which has demonstrated that children with autism respond best in structured and routine activities and have increased difficulty carrying-over knowledge to new environments and activities (Mueller et al., 2007; Richard, 1997; Smith, 2001). Since the activity and routine were changed during the generalization probes, a decrease in performance during these new activities was expected. However, there did appear to be a common theme between the total number of selections and the time at which generalization probes were collected. Generalization probes collected immediately following the end of Phase 1 and Phase 2 showed a greater number of selections than probes collected during the last two weeks of each withdrawal period. This pattern was most likely due to the fact that the learning which occurred in Phase 1 or Phase 2 was more easily carried over to new activities when only a limited amount of time had passed. As more time passed after the withdrawal of teaching sessions, the number of selections tended to decrease.

Cuing and assistance. Similar to the generalization probes, a general theme emerged for the amount of assistance and cuing subjects required as the study progressed. Overall, as the teaching sessions in Phase 1 and Phase 2 progressed, the amount of assistance required by the subjects decreased and the number of independent responses increased. Subjects required more hand-over-hand assistance and specific cues at the start of the study. However, as the teaching sessions continued, these types of cues decreased, and general cues and independent responses became more prominent. These results are consistent with research that has shown that using a least-to-most cuing hierarchy, such as the one employed in the current study, was effective for direct instruction and for preventing individuals from becoming over-reliant on prompts (Durand & Carr, 1991; Reichle et al., 2003; Wacker et al., 1990).

Slight variations in this common theme regarding the amount of assistance were noticed for Subjects 1 and 2. This variability could again be accounted for by the presence of disruptive behaviors on several dates for both subjects, as well as a lack of motivation for and attention to the activities. Subject 3 also demonstrated more variable performance across Phase 2 than the other subjects. This variability in cuing was most likely due to a move along the graded choice continuum for two symbols at the start of Phase 2. As a new foil symbol was added for each of the two target symbols, Subject 3 was no longer required to only select the target symbol but to discriminate between two symbols prior to making a selection. This additional discrimination prior to selecting a symbol resulted in an increase in the amount of cuing. While Subject 4 also moved along the graded choice continuum for two symbols in Phase 2, the introduction of the foil symbols did not occur until the last three teaching sessions and, thus, less variability in the amount of cuing required was seen across Phase 2.

The general decrease seen in the more intrusive forms of cuing for subjects may also have resulted from increased familiarity with tasks. As previously stated, children with autism perform better when routines and tasks are familiar (ASHA, 2006; Mueller et al., 2007; Richard, 1997). Another possible explanation for the increase in independent responses is an increase in the initiation of responses for both subjects as understanding of their role in the communication interaction during the activity increased (i.e., subjects recognized more readily when a response was required).

Concepts versus Comments

The second research question this study attempted to answer was whether an errorless learning teaching strategy was more effective for teaching concepts or comments to children with autism. This research question was more difficult to analyze due to the lack of within-subjects data as the subjects were not exposed to both types of vocabulary (i.e., comments and concepts). However, based on the results of the current study, it appears that errorless learning would be better suited for teaching comments to children with autism as only these subjects moved along the graded choice continuum. However, these results may be due to other factors aside from the ease of learning comments versus concepts. In the study conducted by Quach and Beukelman (2010), the researchers found that the seven-year-old subjects performed better than the six-year-old subjects when taught AAC navigational skills using an errorless learning procedure. The results from the current study are consistent with the results from the Quach and Beukelman study in that the best results were achieved by the subjects with the higher levels of cognitive maturity and language skills. Therefore, the results may not indicate that errorless learning was necessarily better for teaching comments over concepts but that subjects with higher language skills, better attention, and increased interactions with the toys and books learned symbols at a quicker rate. Thus, the effectiveness of errorless learning may depend on more intrinsic factors within the subjects.

Level of Interactions

Throughout the study, informal observations were made regarding the subjects' interactions with the materials used during activities and the subjects' attention to the task during the activities in order to provide further insight.

Subjects 1 and 2 showed minimal changes in their interactions with materials as the study progressed. Errorless learning teaching sessions, weekly probes, and maintenance probes were conducted for both these subjects through play-based activities.

Both Subjects 1 and 2 demonstrated limited interactions with the various toys used during play-based activities (e.g., only placing toys into the box when directly instructed). In addition, both Subjects 1 and 2 showed limited attention to the play-based activities and required frequent verbal prompts during each session to redirect attention to the task. Subject 2 did verbalize responses to questions and redirections such as, "OK", "Where?", "Oh man", "Monkey", and "Let's close." However, most verbalizations were immediate and delayed echolalia, which is a common characteristic of verbal expression in children with autism (ASHA, 2006; Batshaw et al., 2007; Richard, 1997). Subject 2 was also the only subject to respond to prompts with verbal responses.

Generalization probes for Subjects 1 and 2 were conducted through joint book reading activities. During these activities, both subjects showed increased interactions with the book as compared with the toys (e.g., turning pages, lifting flaps). One explanation for these increased interactions is that the subjects were more motivated by the joint book reading task when compared to the manipulative task. In addition, subjects may have been more familiar with joint book reading tasks due to frequent exposure to such tasks in their home and/or school environments. This familiarity with the task may have prompted more interactions as children with autism perform better in familiar contexts (ASHA, 2006; Richard, 1997). However, overall interactions with the book were still limited, and both subjects continued to demonstrate poor attention to tasks. Frequent verbal redirections were required during these joint book reading activities to ensure the subjects were attending to the tasks.

In contrast, observations made regarding Subject 3's and Subject 4's participation showed an increase in interactions with materials over the course of the study. Errorless learning teaching sessions, weekly probes, and maintenance probes were conducted through joint book reading activities for Subjects 3 and 4. Both subjects most often participated by turning pages in the book, pointing to pictures appropriately in the book, pointing to characters after the clinician asked questions regarding them, and giggling at appropriate pictures during joint book reading tasks. Although the subjects' levels of attentiveness to the activity varied across sessions, overall Subjects 3 and 4 required fewer verbal redirections to appropriately attend to the task than did Subjects 1 and 2. As previously discussed, the joint book reading activity may have been more familiar to these subjects as a result of previous exposures during the school day or other speech therapy sessions. The increased familiarity of the joint book reading activities may have helped subjects better attend to the activity and better predict their expected role in the interaction, as compared to a less structured toy/play activity where their role was not specifically defined or had not been established.

During play-based activities for the generalization probes, Subjects 3 and 4 demonstrated an increased interaction with toys and better attention to the tasks as the probes progressed. Interactions included reaching for toys, pointing (e.g., pointing to the nose on the Mr. Potato Head toy when asked what she saw) and counting down with the clinician (e.g., 3…2…1) before blowing bubbles and blowing up balloons. These increased interactions and attention to the tasks may be due to increased understanding of the activities and toys following several examples of play during generalization probes by the researcher or by exposure to these activities within the school or home environment as well as within other speech therapy sessions. Subjects 3 and 4 also navigated through different pages in their devices during generalization probes to state the correct color of a balloon instead of responding appropriately to the yes/no questions posed regarding the color of the toy (e.g., navigating to *yellow* when asked if a balloon was red). This type of interaction may again suggest that these subjects learned the nature of commenting versus learning specific target symbols.

Overall, Subjects 1 and 2 exhibited fewer interactions with the manipulatives during the play-based activities and with the book during the joint book reading activities than did Subjects 3 and 4. Subjects 1 and 2 were also less attentive to the activities than were Subjects 3 and 4. One possible explanation for this difference is that Subjects 3 and 4 may have been more familiar with both types of tasks from school or other speech therapy sessions and, therefore, had a better understanding of appropriate interactions and expectations for both types of activities. Another possible explanation is that the decreased attentiveness exhibited by Subjects 1 and 2 negatively impacted their ability to engage in an activity long enough to demonstrate more appropriate interactions, such as those exhibited by Subjects 3 and 4. The increased levels of interactions and better attention to tasks exhibited by Subjects 3 and 4 may also relate to higher age and ability levels, which enabled them to more quickly and easily understand the expectations of both joint book reading and play-based activities through the multiple models and exposures during the study and possibly in other environments as well (e.g., school and home environments). These higher ability levels may have enabled Subjects 3 and 4 to more readily translate this understanding into more appropriate interactions.

Clinical Impressions

Overall, results from the current study revealed that errorless learning was ineffective to quickly teach new symbols to children with autism who used an AAC device. However, all subjects showed a decrease in the amount of cuing required during teaching sessions, indicating some degree of learning and better initiation of responses following the scripted prompts. The increase in the total number of selections exhibited by all subjects demonstrated that errorless learning may be effective for improving initiation and independence of responding even if responses were inaccurate.

This study also examined errorless learning for teaching both concepts and comments in order to evaluate if the teaching strategy was more effective for one type of symbol over the other. Results were inconclusive as to whether the difference between groups was due to the symbol type or the level of skills present at the start of the study. Due to the variable nature of the results from this study, no clear patterns emerged to definitively determine if errorless learning was a more reliable teaching strategy for one type of symbol acquisition over another for children who use AAC as a primary means of communication.

The integration of the least-to-most cuing hierarchy within the errorless learning teaching strategy for this study enabled subjects to better initiate responses throughout the study. The improved ability to initiate responses was evidenced both by the reduction in more intrusive forms of cuing and the increase in independent responses during the errorless learning teaching sessions. The increase in the total number of symbol selections made by subjects during the probe measures was also indicative of improved initiation. The researcher was unable to prompt subjects to respond during these probes, thus, all responses were initiated by subjects. Smith (2001) stated that a severe limitation of discrete trial training is that children with autism are continually responding to cues from the teacher. The successful combination of the least-to-most cuing hierarchy and the errorless learning teaching strategy in this study demonstrated that not only can the cuing hierarchy prevent prompt dependency, but it may also increase initiation in children with autism, which is a severe limitation of other teaching strategies (e. g., discrete trial training).

Strengths

The current study consisted of several areas of strength, including clinical relevance and high measures of consistency and reliability. The research design allowed for a comparison of learning across a short four-week teaching phase, with symbol acquisition across a longer period of time. The research design also allowed for a comparison of maintenance and generalization skills. In addition, the graded choice continuum allowed subjects to acquire new symbols in the most functional way possible by providing various levels of learning to ensure that subjects' skills were continually improving and being shaped into a more natural context. The successful integration of the least-to-most cuing hierarchy into the errorless learning teaching strategy also enabled subjects to improve symbol acquisition in a functional, clinically relevant way. It allowed cues to be systematically reduced to eliminate prompt dependency and facilitate better initiation of responses by the subjects.

High treatment consistency was another area of strength for this study. The errorless learning strategy was administered consistently to subjects being taught positional concepts and to subjects being taught comments, thus, allowing for a better comparison across subjects. The high inter-rater reliability was another area of strength, indicating consistency in the measurement of skills.

A final area of strength was that the study incorporated more functional vocabulary than standard nouns. Currently, there is little research available in the field of AAC which incorporates vocabulary/symbols which are not nouns or verbs that can be used in requesting or naming items.

Limitations

Although the clinical relevance of the research design was an area of strength, the study could have been stronger by using a group research design versus a single subject research design. A larger number of subjects would have allowed for better comparison of results and generalization to other subjects. Another limitation related to study design was that the subjects were not taught both concepts and comments, which would have enabled a better comparison of results. Other limitations included negative behaviors which affected data collection on several dates for all subjects. These behaviors may have been alleviated if the study included a structured system of behavior control.

A major limitation to this study was the time frame. Extending the length of time would have allowed all subjects to be taught both concepts and comments. Disruptive behaviors may also have been avoided if weekly probes did not have to be collected on the same day as teaching sessions. This study was designed to allow ten minutes for each teaching session as well as for each probe measurement. However, due to schedule conflicts and time conflicts, weekly probes were most often collected immediately following a teaching session. Generalization and maintenance probes were also occasionally collected on the same dates. These longer sessions may have prompted the disruptive behaviors which affected data collection and results. Extending the time frame of the study would have allowed days on which teaching sessions and probes could not be fully administered due to disruptive behaviors to be eliminated, providing a more accurate assessment of the effectiveness of errorless learning as a teaching strategy. The lack of intensity for treatment sessions also limited the scope of this study. Subjects received relatively little intervention over the course of each treatment phase (i.e., only two hours per each four week phase). More intense treatment sessions within the same time frame may have resulted in better symbol acquisition as well.

Future Research

While this study had limited results, it demonstrated the need for future research in the area of errorless learning within the field of speech-language pathology. Replication of this study and similar studies to further assess the validity and reliability of the results would better establish or repudiate errorless learning as an appropriate teaching strategy. Thus far, errorless learning's effectiveness has been investigated for improving communicative competence on AAC systems through teaching operational skills to typically developing children (Quach & Beukelman, 2010) and through teaching linguistic skills to children with autism using an AAC device as in the current study. In order to truly evaluate the efficacy of errorless learning for AAC, these studies should be expanded upon to incorporate larger populations, such as children with autism, cerebral palsy, intellectual disabilities and/or apraxia as well as with children who use an AAC device.

The current study examined errorless learning for teaching functional vocabulary to children with autism. However, there is currently no research regarding the effectiveness of errorless learning for teaching more standard vocabulary such as nouns and verbs. Research is also limited in regards to the pre-requisite cognitive skills individuals need in order to have the readiness level to learn different types of vocabulary and skills. Thus, further investigation is needed to determine the efficacy of errorless learning for teaching a variety of skills including the operational, linguistic, social and strategic skills necessary to achieve communicative competence when using an AAC device, as well as the language skills necessary to achieve competency in verbal communication.

Little evidence is available to support which teaching strategies are most effective and efficient for teaching children who rely on an AAC device as a primary mode of communication. Thus, studies comparing errorless learning to other established teaching strategies, both naturalistic teaching strategies such as aided language modeling and behavioralistic teaching strategies such as discrete trial training, would be beneficial to the field of speech-language pathology in ensuring that clients are receiving the most efficacious treatment possible.

Conclusion

The current study revealed that errorless learning may be an effective strategy for teaching linguistic skills to children with autism who use an AAC device. However, due to the limited number of subjects and the limited time available for this study, the results were not of sufficient significance to determine the true efficacy of errorless learning. The results of the study illustrate the continued need for research in this area of speech-language pathology in order to determine the most efficient and effective teaching strategies for children diagnosed with a developmental disability and for children who use an AAC device as a primary mode of communication.

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Appendix A

IRB Approval

January 29, 2010

Marissa Ulm
Communication Disorders and Sciences

Thank you for submitting the research protocol titled, "A Comparison of Two Strategies for Improving Communication Skills of Children Who Use AAC" for review by the Eastern Illinois University Institutional Review Board (IRB). The IRB has Approved this research protocol following an Expedited Review procedure. IRB review has determined that the protocol involves no more than minimal risk to subjects and satisfies all of the criteria for approval of research.

This protocol has been given the IRB number 10-008. You may proceed with this study from 1/28/2010 to 1/27/2011. You must submit Form E, Continuation Request, to the IRB by 12/27/2010 if you wish to continue the project beyond the approval expiration date.

Please note that if the study will also be conducted in the public school system, a letter of permission to conduct the study from a school administrator must be obtained and forwarded to the EIU Office of Research and Sponsored Programs before data collection may begin.

This approval is valid only for the research activities, timeline, and subjects described in the above named protocol. IRB policy requires that any changes to this protocol be reported to, and approved by, the IRB before being implemented. You are also required to inform the IRB immediately of any problems encountered that could adversely affect the health or welfare of the subjects in this study. Please contact me, or the Compliance Coordinator at 581-8576, in the event of an emergency. All correspondence should be sent to:

Institutional Review Board
c/o Office of Research and Sponsored Programs
Telephone: 581-8576
Fax: 217-581-7181
Email: eiuirb@www.eiu.edu

Upon completion of your research project, please submit Form G, Completion of Research Activities, to the IRB, c/o the Office of Research and Sponsored Programs.

Thank you for your assistance, and the best of success with your research.

John Best, Chairperson
Institutional Review Board
Telephone: 581-6412
Email: jbbest@eiu.edu

March 11, 2010

Marissa Ulm
Communication Disorders and Sciences

Thank you for submitting proposed modifications to the research protocol titled "A Comparison of Two Strategies for Improving Communication Skills of Children Who Use AAC", IRB number 10-008, for review by the Eastern Illinois University Institutional Review Board (IRB). The IRB has reviewed and approved your proposed modifications to the protocol. The approval is effective 3/11/2010. You may continue with your research through 1/27/2011.

The approval of this protocol and its modifications is valid only for the research activities, timeline, and subjects described in the above named protocol. IRB policy requires that any changes to this protocol be reported to, and approved by, the IRB before being implemented. You are also required to inform the IRB immediately of any problems encountered that could adversely affect the health or welfare of the subjects in this study. Please contact me, or the Compliance Coordinator at 581-8576, in the event of an emergency. All correspondence should be sent to:

Institutional Review Board
c/o Office of Research and Sponsored Programs
Telephone: 581-8576

Upon completion of your research project, please submit Form G, Completion of Research Activities, to the IRB, c/o the Office of Research and Sponsored Programs.

Thank you for your assistance, and the best of success with your research.

John Best, Chairperson
Institutional Review Board
Telephone: 581-6412
Email: jbbest@eiu.edu

Appendix B

Informed Consent

CONSENT TO PARTICIPATE IN RESEARCH

The Effectiveness of Errorless Learning for Teaching Concepts and Comments to Children with Autism

You are invited to participate in a research study conducted by Marissa L. Ulm, B.S. and supervised by Trina M. Becker, M.S., CCC-SLP, Angela Anthony, Ph. D., CCC-SLP and Rebecca Throneburg, Ph. D., CCC-SLP from the Communication Disorders and Sciences department at Eastern Illinois University. Your participation in this study is entirely voluntary. Please ask questions about anything you do not understand, before deciding whether or not to participate.

You have been asked to participate in this study because you or your child are an established wants/needs level augmentative and alternative communication (AAC) user who can help us to determine how a new intervention strategy (i.e. errorless learning) will improve the communication abilities of an individual with a developmental disability. Inclusion criteria for participation in this study are that the individual must be an AAC user with a high tech device who has the ability to communicate simple wants and needs, has the ability to directly select from a field of ten symbols, uses American English as his/her primary language, has hearing within normal limits and has corrected or uncorrected vision within normal limits.

- **PURPOSE OF THE STUDY**

The purpose of this study is to examine the effect of using an errorless learning teaching strategy to improve symbol acquisition in children with a developmental disability who are at a wants/needs level of AAC communication. An errorless learning strategy differs from other strategies in that it does not provide an opportunity for an individual to fail. Any symbol selection made is a correct selection. At the same time, this teaching strategy allows an individual to learn new symbols or vocabulary and to discriminate between these symbols. Specific research questions are as follows:

1. To what extent do children with autism improve symbol acquisition skills when instructed using an errorless learning strategy?
    a. Is errorless learning effective for improving symbol acquisition (i.e., correct symbol selections) and/or communicative attempts (i.e., total symbol responses, correct and incorrect) within an activity similar to the teaching context?
    b. Is errorless learning effective for improving symbol acquisition and/or communicative attempts within a new context/activity?

c. Is errorless learning effective for improving initiation and independence of responses for newly acquired symbols?

2. Is an errorless learning teaching strategy more effective for improving symbol acquisition of concepts or comments in children with autism?

- **PROCEDURES**

If you volunteer to participate in this study, you will be asked to:

Participate in two, brief intervention sessions per week, for a period of 5-10 minutes during a regularly scheduled therapy session. Intervention sessions will be conducted at the Eastern Illinois University (EIU) Speech-Language-Hearing Clinic located in the Human Services Center on the second floor. The length of time for participation in this study will be approximately 20-22 weeks.

Data for this study will be collected in five phases: an initial (baseline) phase to assess the participants' abilities prior to intervention, two intervention phases in which the errorless learning teaching strategy will be implemented, and two withdrawal phases in which the teaching strategy or intervention will be removed in order to assess the participants' abilities following intervention.

The baseline phase will be completed in approximately two weeks. Procedures for this phase are as follows:

The participant will be presented with an eight- or ten-symbol set in a grid display on his/her high tech AAC device. Each set will correspond to a specific motivating activity. Symbols used will represent functional vocabulary (e.g., positional concepts, commenting, responses to questions). Symbols will be color coded according to the function of the vocabulary. For example, all concepts will be a blue symbol and all comments will be a pink symbol. Participants will be observed during a joint-book reading or a play-based activity, and data will be collected on the number and type of symbols used.

The intervention phases will be completed in approximately four weeks. Procedures for this phase are as follows:

An errorless learning strategy will be employed. The symbols from the baseline phase will be used in the form of a scripted exchange for each activity with only one symbol (i.e., the correct symbol) presented to the participant at a time. Intervention will require that the high tech device use a dynamic display (i.e., switch display screens). The first display screen will present the participant a target symbol. The researcher will provide a verbal prompt, and the participant will have the opportunity to select a symbol on his/her own. The researcher will wait five seconds before repeating the prompt with the addition of a visual cue (i.e. pointing to the device). If a participant still does not respond after five seconds, the researcher will repeat the verbal prompt with the addition of a specific visual cue (i.e. pointing to a symbol). If the participant still does not respond, the research will use hand-over-hand modeling to aid the participant in selecting the symbol. Similar prompts and cues will be used on each subsequent screen until the exchange is complete. Participants will complete scripts eight times during each intervention phase. Data will be collected on the number and types of symbols that the participant uses as well as the amount of support needed to complete the tasks.

The withdrawal phases will be completed in approximately six weeks. Procedures for this phase are as follows:

The researcher will present the participant with the symbol sets in a traditional grid display. Data will be collected on the number and types of symbols that the participant uses. These data will be used to determine if the intervention was effective.

All subjects participating in this study will be digitally recorded through the use of a video monitoring system currently in place at the EIU Clinic and with the use of a hand-held camera. These digital videos will be reviewed by members of the research team for data collection and analysis purposes.

- **POTENTIAL RISKS AND DISCOMFORTS**

There is minimal risk associated with participation in this study. However, possible short-term risks include participating in a new intervention which may result in no improvement in the areas being targeted. There are no physical risks associated with this research. Psychological risks may include an increase in frustration and/or anxiety for participants, if they have difficulty completing the tasks within the research design.

- **POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY**

Benefits of participating in this study include improvement in the amount of symbols the child uses to communicate. Furthermore, if the treatment is found to be effective in this study, the benefits to the profession of speech-language pathology would include scientific support for an appropriate teaching strategy to improve functional communication abilities in individuals with development disabilities.

- **CONFIDENTIALITY**

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be maintained by means of replacing all participants' names with unidentifiable labels. All data and videos will be saved to restricted research drive on the departmental server. Access to these files will be limited to the researchers and faculty supervisors in order to verify data collection procedures and analysis. All records relating to this research study, including those from subjects who formally withdrew from the study, will be maintained for a period of at least three years. Upon the completion of this time period, all files will be permanently deleted from the computer.

- **PARTICIPATION AND WITHDRAWAL**

Participation in this research study is voluntary and not a requirement or a condition for being the recipient of benefits or services from Eastern Illinois University. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind or loss of benefits or services to which you are otherwise entitled.

- **IDENTIFICATION OF INVESTIGATORS**

If you have any questions or concerns about this research, please contact:
Marissa L. Ulm, B.S.
Telephone: 309-224-0811
Email: mlward@eiu.edu

Trina Becker, M.S., CCC-SLP
Telephone: 217-581-2712
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Email: abanthony@eiu.edu

Rebecca Throneburg, Ph. D., CCC-SLP
Telephone: 217-581-2712
Email: rmthroneburg@eiu.edu

- **RIGHTS OF RESEARCH SUBJECTS**

If you have any questions or concerns about the treatment of human participants in this study, you may call or write:

Institutional Review Board
Eastern Illinois University
600 Lincoln Ave.
Charleston, IL 61920
Telephone: (217) 581-8576
E-mail: eiuirb@www.eiu.edu

You will be given the opportunity to discuss any questions about your rights as a research subject with a member of the IRB. The IRB is an independent committee composed of members of the University community, as well as lay members of the community not connected with EIU. The IRB has reviewed and approved this study.

Appendix C

Materials

Concepts:

Baseline: toy dog, ball, and box

Treatment: toy block, teddy bear, and box

Weekly Probes: toy dog, ball and box

Generalization Probes: *Spot Goes to School* by Eric Hill

Maintenance Probes: toy dog, ball and box

Comments:

Baseline: *David Goes to School* by David Shannon

Treatment: *No, David!* by David Shannon

Weekly Probes: *David Goes to School* by David Shannon

Generalization Probes: balloons, bubbles, rubber rats, dirt with rubber worms, and Mr. Potato Head

Maintenance Probes: *David Goes to School* by David Shannon

Appendix D

Data Sheets

Concepts: Symbol Acquisition and Generalization

Measure Type/Date:									
	Open	Close	Up	Down	In	Out	Under	On	Total
Trial 1									
Trial 2									
Trial 3									
Trial 4									
Trial 5									
Trial 6									
Trial 7									
Trial 8									
Trial 9									
Trial 10									
Trial 11									
Trial 12									
Trial 13									
Trial 14									
Trial 15									
Trial 16									
Trial 17									
Trial 18									
Trial 19									
Trial 20									
Trial 21									
Trial 22									
Trial 23									
Trial 24									
Total Correct									
Total Incorrect									

Concepts: Assistance and Cuing

Measure Type/Date:				
	Independent	General Cue	Specific Cue	Hand-over-hand
Open				
Trial 1				
Trial 2				
Trial 3				
Trial 4				
Percentage				
Under				
Trial 1				
Trial 2				
Trial 3				
Trial 4				
Percentage				
On				
Trial 1				
Trial 2				
Trial 3				
Trial 4				
Percentage				
In				
Trial 1				
Trial 2				
Trial 3				
Trial 4				
Percentage				
Total				
Total Percentage				

Concepts: Assistance and Cuing (Graded-choice tracking)

Measure Type/Date:					
	Open	In	Under	On	Total
Independent					
Percentage					
General Cue					
Percentage					
Specific Cue					
Percentage					
Hand-over-hand					
Percentage					

Comments: Symbol Acquisition and Generalization

Measure Type/Date:											
	Yes	No	That's Silly	Uh-oh	Yucky	Cool	Fun	I Like	I Don't Like	Look	Total
Trial 1											
Trial 2											
Trial 3											
Trial 4											
Trial 5											
Trial 6											
Trial 7											
Trial 8											
Trial 9											
Trial 10											
Trial 11											
Trial 12											
Trial 13											
Trial 14											
Trial 15											
Trial 16											
Trial 17											
Trial 18											
Trial 19											
Trial 20											
Trial 21											
Trial 22											
Trial 23											
Trial 24											
Trial 25											
Trial 26											
Trial 27											
Trial 28											
Trial 29											
Trial 30											
Correct Responses											
Incorrect Responses											
Additional Appropriate Comments											

Comments: Assistance and Cuing

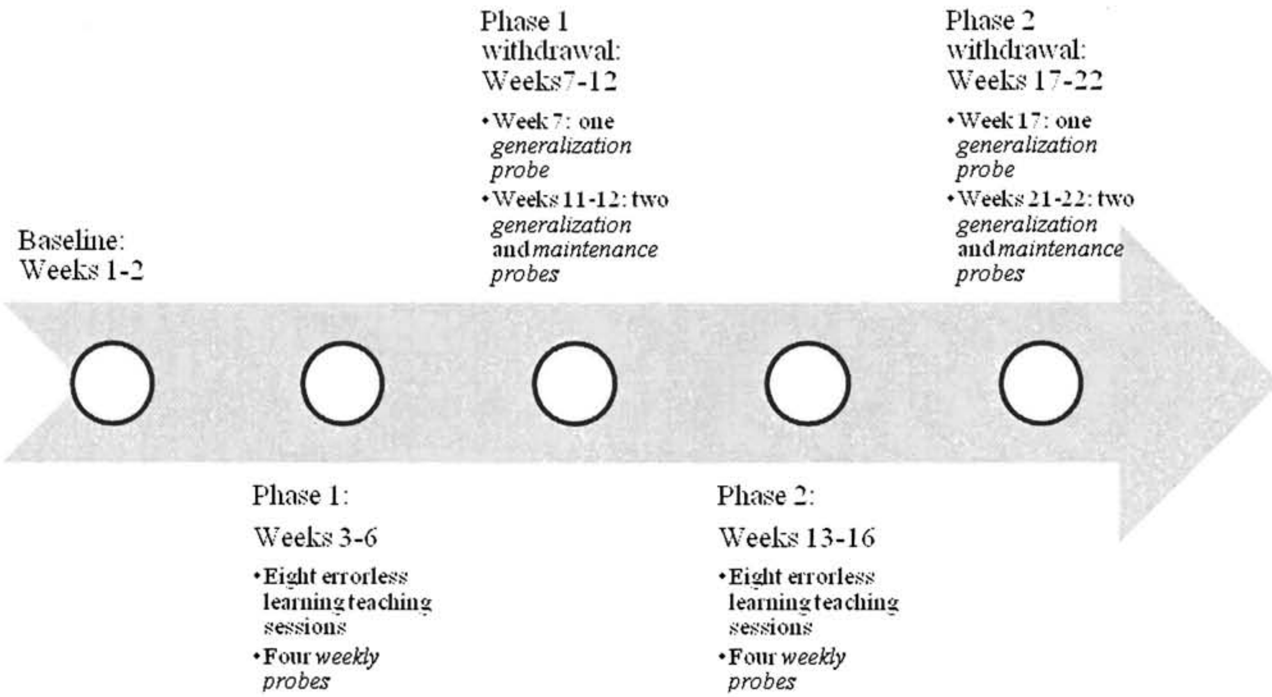
Measure Type/Date:				
	Independent	General Cue	Specific Cue	Hand-over-hand
Yes				
Trial 1				
Trial 2				
Trial 3				
Trial 4				
Percentage				
No				
Trial 1				
Trial 2				
Trial 3				
Trial 4				
Percentage				
That's Silly				
Trial 1				
Trial 2				
Trial 3				
Trial 4				
Percentage				
Uh-oh				
Trial 1				
Trial 2				
Trial 3				
Trial 4				
Percentage				
Yucky				
Trial 1				
Trial 2				
Trial 3				
Trial 4				
Percentage				
Total				
Total Percentage				

Comments: Assistance and Cuing (Graded-choice tracking)

Measure Type/Date:						
	Yes	No	That's Silly	Uh-oh	Yucky	Total
Independent						
Percentage						
General Cue						
Percentage						
Specific Cue						
Percentage						
Hand-over-hand						
Percentage						

Appendix E

Study Timeline



Appendix F

Scripted Exchanges

Comments: Baseline, Weekly Probe, and Maintenance Probe Script
David Goes to School

Page 1
Clinician (C) : David's teacher always said…No, David.
C: Look at the picture he drew!
C: What do you think?
Subject (S) That's silly!
C: It is silly!

Page 2
C: David's at school! Look at his room.
C: I see a fish. (Point)
C: Do you see anything?
S: Look!
C: Reinforce if they point to something or if no response, point to something else and name it.

Page 3
C: Sit down, David!
C: He's making a funny face. What do you think about that?
S: That's silly!
C: That is silly!

Page 4
C: Don't chew gum in class!
C: (Gasps) What's happening?
S: Uh, oh!
C: Oh no! Is that gum?
S: Yes.
C: It is gum!
C: He's all sticky! How does he look?
S: Yucky!
C: What do you think about it?
S: I don't like.
C: No, it's gross!

Page 5
C: Look at what David has! (Point to book)
C: Is that a book?
S: Yes.
C: It is a book!

Page 6
C: They're painting! What do you think?
S: Fun!
C: Painting is fun.
C: Look at all his paints!
C: Is this green paint? (Point to the blue paint)
S: No.
C: No, it's blue!
C: Look at his picture. (Point) What do you think?
S: I like.
C: What's going on? (Point to page)
S: Uh oh!
C: Uh oh, he's gonna put paint in her hair! What do you think?
S: I don't like.
C: I don't like it either.

Page 7
C: Pay attention!
C: Is David looking at his teacher?
S: No.
C: No, he's looking out the window.
C: Look at the clouds! (Point) I see a dinosaur. What do you think of that?
S: Cool!
C: Yeah. Do you see anything?
S: Look!
C: Reinforce if they point to something or if no response, point to something else and name it.

Page 8
C: Wait your turn, David!
C: Look at David. Is there milk on his tray? (Point)
S: Yes.
C: He does have milk.
C: Look at the food. (Point) How does it look?
S: Yucky!
C: Yeah it does. What do you think about it?
S: I don't like.
C: I don't like either!

Page 9
C: Look at what happened! What do you think?
S: Uh oh!
C: Yeah, they're in trouble!
C: There's food all over the floor! Look at the spilled milk (Point).
C: What do you see?
S: Look!

C: Reinforce if they point to something or if no response, point to something else and name it.
C: How do the boys look?
S: Yucky!
C: They do look yucky!

Page 10
C: David! Recess is over!
C: Look he's playing with a ball. What do you think?
S: Fun!
C: Look at how high the ball is! (Point) What do you think?
S: Cool!
C: Yeah, it's high!

Page 11
C: David's being silly!
C: Look at all the books? What do you think?
S: I like.
C: Yeah, books are great!

Page 12:
C: Again?!
C: Is David sitting?
S: No.
C: No, he's standing up!
C: Look at how he's standing! What do you think?
S: That's silly.
C: He does look silly.

Page 13
C: That's it, Mister! You're staying after school!
C: Look at his desk! (Point) What do you think?
S: I like.
C: Yeah, he drew some cool pictures!

Page 14
C: David, have you finished?
C: He's all done.

Page 15
C: Good job, David!
C: Look! He got a star! What do you think?
S: Cool!
C: Pretty cool!

Page 16
C: Yes, David…You can go home now.
C: Look he's gonna go play.
C: What do you think about that?
S: Fun!
C: Playing is fun!

Comments: Errorless Learning Teaching Script
No, David!

Page 1
Clinician (C): David's mom always said...No, David.
C: Look at what he did to the wall!
C: What do you think?
Subject (S): Uh oh!
C: Uh oh, he colored on the wall!

Page 2
C: No, David!
C: He's trying to steal cookies!

Page 3
C: No, David, no!
C: What's he look like?
S: Yucky!
C: Yeah, he's all dirty and yucky!
C: Is that a worm?
S: Yes.
C: Yes, it is worm. He has a worm on his face!

Page 4
C: Bath time!
C: Is that a duck? (Point to shark)
S: No.
C: No, that's a shark. Here's a duck.
C: Look at what he's wearing! (Point to David)
C: What do you think?
S: That's silly!
C: Oh no! The water's spilling out of the tub! What do you think?
S: Uh oh!
C: Uh oh, there's water on the floor!

Page 5
C: Come back here, David!
C: Look at him! What do you think?
S: That's silly!
C: He's silly...he forgot his clothes.
C: Is that a dog?
S: Yes.
C: You're right. The dog's looking at silly David.

Page 6
C: Look at David. He's wearing a pot on his head! What do you think about that?
S: That's silly!
C: He does look silly!

Page 7
C: David's eating dinner.
C: Look. (Point to spoon) Is that a fork?
S: No.
C: No, it's a spoon!
C: Don't play with your food, David!
C: What do you think? (Point to man made out of food.)
S: That's silly!
C: Silly David...he made a man out of his food!

Page 8
C: That's enough, David!
C: Look at that! What do you think?
S: Yucky!
C: Yucky, he's chewing with his mouth open.

Page 9
C: Go to your room!
C: Oh, no. David's mad.

Page 10
C: Settle down! What's happening?
S: Uh oh!
C: Uh oh, he's jumping on his bed!
C: Look at his bed! Is that a bear?
S: Yes.
C: It is a bear. Are those bears? (Point to the blanket?)
S: No.
C: No, they're planes!

Page 11
C: Stop that this instant!
C: What do you think?
S: Yucky!
C: He's picking his nose!

Page 12
C: Put your toys away!
C: Look at the floor! Is that ball? (Point to bulldozer.)
S: No.
C: No, it's a truck.

C: What do you think? (Point to the mess on the floor.)
S: Yucky!
C: Yucky! It's all messy!

Page 13
C: Not in the house, David!
C: Does he have a ball? (Point)
S: Yes.
C: Yes, he does.

Page 14
C: I said no, David!
C: What happened? (Point to broken vase.)
S: Uh oh!
C: Oh no! He broke the vase!

Page 15
C: Davey, come here.
C: He looks sad.

Page 16
C: Yes, David…I love you!
C: Now, he's happy.

Comments: Generalization Probe Script
Manipulatives

Clinician (C): Let's see what's in our fun box!
C: Look at all the stuff!
C: What do you think?
Subject (S): Cool!
C: There's lots of cool stuff in there.
C: Look, I see bubbles.
C: What do you see?
S: Look !
C: If they point to something or grab something, reinforce; otherwise point to something else and name it.

Bubbles
C: Let's play with bubbles.
C: What do you think?
S: Fun!
C: Bubbles are fun.
C: (Blow bubbles and pop the bubbles).
C: What do you think about that?
S: I like.
C: I like too. Let's blow more.
C: (Pretend to blow bubbles but don't actually).
C: What happened?
S: Uh oh!
C: Uh oh. No bubbles.
C: (Blow bubbles & point to one) Is that a bubble?
S: Yes
C: It was a bubble.
C: (Point to something different) Is that a bubble?
S: No.
C: No, that's a ___________ (Name the object you pointed to).
C: OK, let's blow a big bubble. (Blow bubble).
C: What do you think?
S: Cool!
C: It was so cool! You're right.

Dirt & Worms
C: Let's play with something new.
C: (Open box and pull out tub of dirt). What do you think about this?
S: Yucky!
C: It is yucky.
C: Do you like it?
S: I don't like.
C: No I don't like it either.

C: Look at the worms!
C: What do you think?
S: Yucky!
C: They are yucky!

Mr. Potato Head
C: Let's play with Mr. Potato Head.
C: What do you think?
S: Fun!
C: It is fun.
C: What do you think? (Mr. Potato Head will already be put together and look silly)
S: That's silly!
C: It is silly!
C: Look, I see his nose. (Point)
C: What do you see?
S: Look!
C: If they point to something or grab something, reinforce; otherwise point to something else and name it.
C: (Make something fall off Mr. Potato Head). What happened?
S: Uh oh!
C: Uh oh! His __________ fell off. (Name object).
C: (Point to his mouth). Is that his mouth?
S: Yes.
C: You're right. It is his mouth.
C: Is that his nose? (Point to something else).
S: No.
C: No, it's his _________. (Name object).
C: (Put on new pieces) What do you think?
S: That's silly!
C: You're right. It's still silly.
C: Do you like Mr. Potato Head?
S: I like.
C: I like him too!

Rats
C: OK. Let's look in our box.
C: Look, I see rats.
C: Do you like rats?
S: I don't like.
C: I don't like either.
C: How do they look?
S: Yucky!
C: They do look yucky.
C: Let's put them back. What else is in our box?
S: Look!

C: If they point to something or grab something, reinforce; otherwise point to something else and name it.

Balloons

C: Let's play with balloons.
C: Do you like balloons?
S: I like.
C: I like them too!
C: Is this a red balloon?
S: No.
C: No, it's blue.
C: Is this a red balloon?
S: Yes.
C: You're right. It is red.
C: Let's blow it up. (Blow up big).
C: What do you think?
S: Cool!
C: It is cool!
C: Let's let it go!
C: What do you think?
S: That's silly!
C: It is silly. Let's do another one.
C: (Pretend to blow up a balloon but don't actually). What happened?
S: Uh oh!
C: Uh oh, it didn't blow up.
C: What do you think about that?
S: I don't' like.
C: I don't like it either. Let's try again.
C: (Blow it up and let it go) What do you think?
S: Fun!
C: It is fun!

Concepts: Baseline, Weekly Probe, and Maintenance Probe Script
Manipulatives

Clinician (C): Let's play with some toys!

Prompt 1:
C: Let's see what's in the box!
C: What should we do?
Subject (S): Open.
C: Open the box.
C: Look! There are toys in the box.
C: Where are the toys?
S: In.
C: In the box!
C: Let's play with the ball. (Take out the ball and put it next to the box) Look! The ball is out of the box.
C: Where is the ball?
S: Out.
C: You're right. The ball is out of the box.
C: Now what should we do with the box?
S: Close.
C: Close the box.

Prompt 2:
C: Let's put the ball under the table.
C: Where is the ball?
S: Under.
C: Under the table.
C: Now let's put the ball on the table.
C: Where is the ball?
S: On.
C: On the table.

Prompt 3:
C: (Put the ball up on the shelf) Look! The ball is up!
C: Where is the ball?
S: Up.
C: The ball is up!
C: (Move the ball to the floor). Now the ball is down!
C: Where is the ball?
S: Down.
C: The ball is down.

Prompt 4:
C: Let's open the box again! (Open the box)
C: What did we do?

S: Open.
C: Opened the box!
C: Look the dog is in the box!
C: Where is the dog?
S: In.
C: The dog is in!
C: Let's take the dog out!
C: Where is the dog?
S: Out.
C: The dog is out of the box.
C: Now what should we do with the box?
S: Close.
C: Close the box.

Prompt 5:
C: Let's put the dog on the table!
C: Where is the dog?
S: On.
C: On the table!
C: (Move the dog under the table). The dog is under the table.
C: Where is the dog?
S: Under.
C: He's under the table.

Prompt 6:
C: (Put the dog up on the shelf) Look! The dog is up!
C: Where is the dog?
S: Up.
C: The dog is up!
C: (Move the dog to the floor). Now he's down!
C: Where is he?
S: Down.
C: He's down.

Prompt 7:
C: (Put the dog on the table and the ball under).
C: Now the ball is under the table.
C: Where is the ball?
S: Under.
C: Under the table.
C: The dog is on the table.
C: Where is the dog?
S: On.
C: The dog is on. He's on the table and the ball is under the table

Prompt 8:
C: (Put the ball up on a shelf and the dog on the floor)
C: Look the dog is down and the ball is up!
C: Where is the dog?
S: Down.
C: Yeah, he's down.
C: Where is the ball?
S: Up.
C: The ball is up.

Prompt 9:
C: Time to put the toys away! Let's open the box!
C: What do we do?
S: Open.
C: Open the box.
C: (Put the ball in the box) Look the ball is in the box and the dog is out of the box.
C: Where is the ball?
S: In.
C: The ball is in the box.
C: Where is the dog?
S: Out.
C: The dog is out. Let's put the dog in too.
C: OK, we're all done with the box. Let's close the box!
C: What do we need to do?
S: Close.
C: Yes. Close the box!

Concepts: Errorless Learning Teaching Session Script
Manipulatives

Prompt 1:
Clinician (C): Let's play!
C: We need to open the box. What should we do?
Subject (S): Open.
C: Open the box.
C: Look! The toys are in the box!
C: Where are the toys?
S: In.
C: You're right. They're in the box.
C: Let's play with the block first. (Take out the block and close the box).

Prompt 2:
C: Let's put the block under the table. (Place the block in position as you say it).
C: Where is the block?
S: Under.
C: Yes, the block is under the table.
C: Now let's put the block on the table. (Place the block in position as you say it).
C: Where is the block?
S: On.
C: It's on the table.

Prompt 3:
C: Where should we hide it now?
C: Hmmm...let's put it under the chair. (Place the block in position as you say it).
C: Where is the block?
S: Under.
C: Yes, the block is under.
C: Let's put it on the chair. (Place the block in position as you say it).
C: Where is the block now?
S: On.
C: It is on the chair.

Prompt 4:
C: Let's get the other toy, now.
C: We need to open the box.
C: What do we do?
S: Open.
C: We need to open the box. (Open the box as you say it).
C: Look, there's the bear. He's in the box.
C: Where is bear?
S: In.
C: Bear's in the box.
C: Let's get him out. (Take out the bear and close the box).

Prompt 5:
C: OK. Let's hide bear now. (Put bear under the table)
C: Look, he's under the table.
C: Where is the bear?
S: Under.
C: Under the table.
C: Let's put the block on the table. (Place the block in position as you say it).
C: Where is the block?
S: On.
C: It's on the table.

Prompt 6:
C: OK. We're all done with the block.
C: Time to put it away. We need to open the box.
C: What do we do with the box?
S: Open.
C: Open the box. (Open the box as you say it).
C: Let's put the block in the box. (Place the block in position as you say it).
C: Where is the block?
S: In.
C: The block is in the box.
C: All done block. (Close the box).

Prompt 7:
C: Let's hide bear again.
C: We'll hide him under the chair. (Place the bear in position as you say it).
C: Where is bear?
S: Under.
C: You're right. He's under the chair.
C: Now, let's put him on the chair. (Place the bear in position as you say it).
C: Where is bear?
S: On.
C: He's on the chair.

Prompt 8:
C: OK. We're all done with bear.
C: We need to open the box and put him away.
C: What do we do with the box?
S: Open.
C: We open the box. (Open the box as you say it).
C: Let's put bear in. (Put the bear inside as you say it).
C: Where's bear?
S: In.
C: He's in the box.
C: OK. We're all done. (Close the box).

Concepts: Generalization Script
Spot Goes to School

Page 1:
Clinician (C): Spot starts school today!

Page 2:
C: Good morning, Miss Bear.
C: I wonder who is behind the door.
C: What should we do?
Subject (S): Open.
C: Open the door.
C: Spot's friends are in the school.
C: Where is Spot?
S: Out.
C: Spot is out of the school.
C: Now what should we do?
S: Close.
C: Close the door.

Page 3:
C: Let's start with a song, but where's Spot?
S: Under.
C: Under the table.
C: Where is monkey?
S: On.
C: On the table.

Page 4:
C: What has Spot found in the playhouse?
C: Let's find out. What do we need to do?
S: Open.
C: Open the door.
C: Spot found dress-up clothes in the playhouse!
C: Where did Spot find the clothes?
S: In.
C: In the playhouse.
C: Now what should we do?
S: Close.
C: Close the door.
C: Where is Tom?
S: In.
C: In the playhouse.
C: Where is Helen, the hippo?
S: Out.
C: She's out of the playhouse?

Page 5:
C: Look! Spot is building a tower.
C: Where will he put the last block?
S: On.
C: On the other two.
C: Oh no! The blocks look like they're going to fall. Where will they fall?
S: Down.
C: The blocks will fall down.

Page 6:
C: Spot and his friends brought some things for Show-and-Tell.
C: Where are all the things?
S: On.
C: On the table, that's right.

Page 7:
C: The playground is fun! Look at everyone.
C: Tom and Spot are on the see-saw.
C: Where is Tom?
S: Down.
C: And where is Spot?
S: Up.
C: Tom is down and Spot is up.
C: Where is Helen sliding?
S: Down.
C: Down into the sand box.
C: I see a bird. Where is it?
S: Up.
C: Up in the tree.
C: Look at the pretty flowers. Where are they?
S: Under.
C: Under the tree.

Page 8:
C: It's time for a story!
C: Where is Tom?
S: Under.
C: Under Spot.

Page 9:
C: Where is Spot looking?
S: In.
C: In the paint box.
C: What's in the paint box? What should we do?
S: Open.

C: Open the box.
C: Look there are red, green, and blue paints.
C: Now what should we do?
S: Close.
C: Close the paint box.
C: Where is the paintbrush?
S: Out.
C: Out of the paint box.

Page 10:
C: It's time for Spot to go home.

Page 11:
C: How was school, Spot?
C: Great!
C: Look at all the pictures.
C: Where is Monkey holding his picture?
S: Up.
C: Up in the air so that his mom can see it.

Appendix G

Distribution of Responses

Subject 1

Symbol Acquisition Phase 1

	Weekly Probe 1		Weekly Probe 2		Weekly Probe 3		Weekly Probe 4		Maintenance Probe 1		Maintenance Probe 2	
Open	1	1	1		2		2		0		1	
Close	2		0		1		1	1	4		2	
Up	6		1		7		9	1	7	1	5	1
Down	0		1		2		0		0		0	1
In	0		1		0		0		0		0	
Out	7		7		4		4	1	7	1	0	
Under	1		0		0		0		0		0	
On	0		1		0		0		0		0	

Symbol Acquisition Phase 2

	Weekly Probe 5		Weekly Probe 6		Weekly Probe 7		Weekly Probe 8		Maintenance Probe 3		Maintenance Probe 4	
Open	1		1		2		3		1		0	
Close	1		0		1		1		0		0	
Up	5	3	8		4		2		1		0	
Down	3	1	4		0		2		0		0	
In	0		0		1		0		0		0	
Out	5		7		2		7	1	1	1	0	1
Under	0		0		0		1		0		0	
On	0		1		0		0		0		0	

Generalization Phase 1 and 2

	Generalization Probe 1		Generalization Probe 2		Generalization Probe 3		Generalization Probe 4		Generalization Probe 5		Generalization Probe 6	
Open	2		0		0		3		3		2	
Close	0		2		0		0		3		3	
Up	5		5	2	6		8	2	2	1	6	1
Down	0	1	0		0	1	0		1		0	
In	0	1	0		0		1		2		0	
Out	1	1	5		0		2		2		3	
Under	1		0		0		0		0		0	
On	0		0		0		0		1		0	

Key: Incorrect selections-first column; Correct selections- second column
*Totals may not match results charts as multiple symbols were hit for one elicited opportunity

Subject 2

Symbol Acquisition Phase 1

	Weekly Probe 1	Weekly Probe 2	Weekly Probe 3	Weekly Probe 4	Maintenance Probe 1	Maintenance Probe 2
Open	0	0 1	0 1	1 1	1	2
Close	0	3	0	1	2	4
Up	0	0	0	0	0	1
Down	0	0	0	0	0	1
In	0	0	0	1	0	0
Out	0	12 2	12 2	12	6	1
Under	0	0	0	0	0	0
On	0	0	0	0	0	0

Symbol Acquisition Phase 2

	Weekly Probe 5	Weekly Probe 6	Weekly Probe 7	Weekly Probe 8	Maintenance Probe 3	Maintenance Probe 4
Open	1	0	0	0	0	0
Close	0	1	0	0	0	0
Up	0	0	0	0	0	0
Down	0	0	0	0	0	0
In	0	0	0	0	0	0
Out	13 2	19 3	18 2	18 3	0	0 1
Under	0	0	0	0	0	0
On	0	0	0	0	0	0 1

Generalization Phases 1 and 2

	Generalization Probe 1	Generalization Probe 2	Generalization Probe 3	Generalization Probe 4	Generalization Probe 5	Generalization Probe 6
Open	0	0	1	0	0	0
Close	0	0	1	0	0	0
Up	0	0	0	0	0	0
Down	0	0	0	0	0	0
In	0	0	0	0	0	0
Out	0	2	0	16 2	0	0
Under	0	1	0	0	0	0
On	0	0	0	0	0	0

Key: Incorrect selections-first column; Correct selections- second column
*Totals may not match results charts as multiple symbols were hit for one elicited opportunity

Subject 3

Symbol Acquisition Phase 1

	Weekly Probe 1	Weekly Probe 2	Weekly Probe 3	Weekly Probe 4	Maintenance Probe 1	Maintenance Probe 2
Yes	N/A	0	0	0	0	0
No	N/A	0	0	0	0	1
That's Silly	N/A	1	0	0	0	0
Uh-oh	N/A	0	0	0	0	0
Yucky	N/A	0	0	0	0	0
Cool	N/A	0	0	0	0	0
Fun	N/A	0	0	0	1 0 1	0
I like	N/A	0	0	0	0	0
I don't like	N/A	0	0	0 1	0	0
Look	N/A	0	0	34 2 33	0	0

Symbol Acquisition Phase 2

	Weekly Probe 5	Weekly Probe 6	Weekly Probe 7	Weekly Probe 8	Maintenance Probe 3	Maintenance Probe 4
Yes	0	0	0	0	1	0
No	0	0	4 0 2	0	1	2
That's Silly	0	1	1 0 1	4 0 2	0	0
Uh-oh	0	0	0	6 0 1	1	0
Yucky	1	4 0 1	1 1	0	0	0
Cool	0	0	0	0	0	0
Fun	0	0	1	0	0	4 1 3
I like	0	0	0 1	0	1 0 1	0
I don't like	0	0	1 0 1	0	0	0
Look	1 0 1	0	2 0 2	2 0 1	0	0

Generalization Phases 1 and 2

	Generalization Probe 1	Generalization Probe 2	Generalization Probe 3	Generalization Probe 4	Generalization Probe 5	Generalization Probe 6
Yes	2 0 1	0	0	0	1	1
No	1 1 0	0	0	0	1	3 0 1
That's Silly	0	0	0	0	0	0
Uh-oh	0	0	0	0	1	0
Yucky	0	0	0	0	0	0
Cool	1 0 1	0	0	0	0	0
Fun	0	9 1 7	0	1 0 1	1 0 1	5 0 3
I like	3 0 3	0	0	1 0 1	0	0
I don't like	0	0	0	0	0	0
Look	6 0 8	0	0	0	0	1 0 1

Key: Incorrect selections-first column; Correct selections- second column; Additional appropriate comments-third column

*Totals may not match results charts as multiple symbols were hit for one elicited opportunity

Subject 4

Symbol Acquisition Phase 1

	Weekly Probe 1	Weekly Probe 2	Weekly Probe 3	Weekly Probe 4	Maintenance Probe 1	Maintenance Probe 2
Yes	N/A	N/A	0	N/A	0	0
No	N/A	N/A	1	N/A	0	0
That's Silly	N/A	N/A	0	N/A	0	0
Uh-oh	N/A	N/A	0	N/A	0	0
Yucky	N/A	N/A	1	N/A	0	0
Cool	N/A	N/A	0	N/A	0	0
Fun	N/A	N/A	0	N/A	0	0
I like	N/A	N/A	0	N/A	0	0
I don't like	N/A	N/A	0	N/A	0	0
Look	N/A	N/A	0	N/A	0	0

Symbol Acquisition Phase 2

	Weekly Probe 5	Weekly Probe 6	Weekly Probe 7	Weekly Probe 8	Maintenance Probe 3	Maintenance Probe 4
Yes	0	0	0	0	0	0
No	0	0	0	0	0	0
That's Silly	0	0	0	0	0	0
Uh-oh	0	0	0	0	0	0
Yucky	0	0 1	0	0	0	0
Cool	0	0	0	0	0	0
Fun	0	0	0	0	0	0
I like	15 3 15	10 1 9	22 3 11	18 2 14	3 2 2	8 2 5
I don't like	0	0	0	0	0	0
Look	0	0	0	0	0	0

Generalization Phases 1 and 2

	Generalization Probe 1	Generalization Probe 2	Generalization Probe 3	Generalization Probe 4	Generalization Probe 5	Generalization Probe 6
Yes	0	0	0	0	0	0
No	0	0	0	0	0	0
That's Silly	0	0	0	0	0	0
Uh-oh	0	0	0	0	0	0
Yucky	0	0	0	0	0	0
Cool	0	0	0	0	0	0
Fun	0	0	0	0	0	0
I like	16 2 10	0	0	1 0 1	2 1 1	1 0 1
I don't like	0	0	0	0	0	0
Look	0	0	0	0	0	0

Key: Incorrect selections-first column; Correct selections- second column; Additional appropriate comments-third column

*Totals may not match results charts as multiple symbols were hit for one elicited opportunity