FACILITATING MULTISYLLABIC PRODUCTIONS WITH A HYBRID TREATMENT APPROACH IN THREE PRESCHOOL-AGE CHILDREN

BY

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THESIS

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ABSTRACT

A single-subject multiple baseline design across target sets examined the effectiveness of a hybrid treatment approach, incorporating both linguistic and motor learning strategies, to facilitate multisyllabic productions in three preschool-age children who were at the single-word stage of development. Key to this design was the selection of thirty multisyllabic targets: 15 treatment and 15 control that were matched based on semantic category and phonetic complexity. Overall, results indicated positive gains in two of the three children that could be attributed directly to the applied treatment. Specifically, two of the children produced gains in the treated target sets relative to those that had not yet been treated. In addition, gains in the treated targets as a whole exceeded gains in the control targets that were never explicitly treated. Although the third child did not demonstrate a treatment effect through the probes and assessments, she did produce many of the target forms during the actual treatment phases, reaching mastery on two of the three target sets. Overall the hybrid approach appeared most promising for children with motor planning breakdowns, with or without a concomitant ASD diagnosis, explicitly if basic symbolic understanding and communicative intent have emerged. Particularly promising strategies included: access to a speech-output device, use of functional carrier phrases within meaningful communicative routines, and modeling of targets with varied intonation patterns. This present document is intended to help provide specific examples of how such strategies could be implemented within the context of a hybrid intervention, and to highlight the importance of thinking about the specific cognitive processes that may be underlying speech-language difficulties.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER I

Literature Review

The purpose of the proposed within-subject study is to examine the effectiveness of a hybrid treatment approach in facilitating children's multisyllabic productions. The introduction begins with a review of key developmental stages leading up to children's use of multisyllabic productions, followed by a discussion of the cognitive processes involved in the production of this important developmental milestone. Finally, this chapter provides an overview of evidence-based practices focused on facilitating multisyllabic productions in children with developmental difficulties in the domains of cognitive-linguistic processing and motor planning.

Key Developmental Phases

This review of typical linguistic development from babbling to word productions and word combinations was guided largely by a recent article by Tager-Flusberg et al. (2009), which provided a developmental framework with five key phases in the acquisition of spoken language. For this review, the focus will be on phases 1 through 3. Phase 1 is defined as preverbal, phase 2 as first words, and phase 3 as word combinations. Tager-Flusberg et al. acknowledge that although developmental benchmarks are often described as phases, natural development occurs in a dynamic and overlapping manner, thus the phases represent general guidelines rather than definite boundaries. The following text highlights the three developmental phases leading up to and encompassing multisyllabic productions by integrating details from other sources.

Phase 1: Preverbal Communication

The word prelinguistic refers to the developmental period prior to the acquisition and intentional use of first words (Wetherby, Warren, & Reichle, 1998). Infants' early vocalizations are largely vowel-like and imprecise in nature due to structural differences and limitations in motor control (Stoel-Gammon, 1985). Early consonant sounds such as stops tend to emerge around 7 - 9 months (Stoel-Gammon & Dunn, 1985). The first syllable combinations are typically observed in reduplicated babbling around 7 - 9 months of age, which consists of repeated CV syllables (e.g., baba), followed by variegated forms (e.g., bada) around the age of 10 - 12 months (Stoel-Gammon & Dunn, 1985). Variegated babbling represents a more phonologically complex form, which is often described as resembling adult-like speech (Elbers, 1982; Hodson, 2007; Stark, 1980; Stoel-Gammon, 1992). In fact, infant babbling has been interpreted as the phonological foundation of children's first words (Stoel-Gammon, 1998). Additionally, Wilcox and Shannon (1998) suggested that diverse phonetic repertoires and syllable shapes are indicators of readiness for development of first-words.

Phase 2: First Words

Transitioning from babbling to the use of meaningful speech is a critical milestone that may be marked as moving from a prelinguistic period to a linguistic phase. This milestone typically occurs between the ages of 9 to 18 months. Overlap between the first two phases occurs quite often, as babbling and meaningful speech may be used simultaneously within a single utterance (Hodson, 2007; Stoel-Gammon & Dunn, 1985). Nip, Green, and Marx (2009) made the following distinction between productions of babbling and meaningful words: infant babbling may be made up of adult-like phonemes; however, words require more linguistic and cognitive processing demands due to the implementation of specific phoneme targets and communicative intentions.

During the first words phase, typical consonant inventories are made up of stops, nasals, and glides (Bleile, 2004). These individual phonemes are inserted into the language-designed "frame" of words that include a variety of phonological structures, such as open syllables (CV), closed syllables (CVC), and combinations therein (CVCVC) (Velleman, 2003). The frame and phonetically established content do not solely determine the first intentional linguistic forms; rather the application of consistent meanings must be achieved as well. Wilcox and Shannon (1998) expanded on this notion by stating that the first words are symbolic even though they may not be considered fully linguistic due to the lack of a rule-governed system. The growth of a child's lexicon is fairly slow and steady until about 18-21 months. Then, after the child acquires approximately 20 to 50 words, a vocabulary burst generally occurs (Wetherby, Reichle, & Pierce, 1998), in which the lexicon is expanded at a dramatic rate aided through processes such as fast-mapping (Carey & Bartlett, 1978). At this point in development typical children are using both verbal and nonverbal forms for a variety of communicative intentions, including protesting, requesting, commenting, and responding (Bruner, 1981; Carpenter, Mastergeorge, & Coggins, 1983; Wetherby, Cain, Yonclas, & Walker, 1988).

Phase 3: Word Combinations

In transition between the first word acquisition phase and the word combination phase children begin to shape open syllables into closed syllables. Around the age of 24-months typically developing children tend to articulate various syllable shapes from simple forms (e.g., V or VC) to more complex forms (e.g., CVCVC) (Bleile, 2004). Moving from individual syllables (e.g., consonant and a vowel, or sometimes just a vowel) to syllable combinations marks a critical stage in speech and language development. This acquired skill aids with increasing intelligibility and with expanding the overall functionality of communicative intentions (Tager-Flusber et al., 2009). For an example, word combinations and/or the use of multisyllabic words help children differentiate various communication intentions (e.g., requesting, commenting, protesting), use specific semantics (e.g., truck v. bulldozer), and develop more mature syntactic forms (e.g., big boy, no more, crying).

This combination of words and use of more matured word forms (e.g., multisyllabic words) tends to occur shortly after the vocabulary burst, around the age range of 18-30 months (Tager-Flusberg et al., 2009; Wetherby, Reichle, et al., 1998). This is also when a child develops a functional language system firmly established on a syntactic foundation. Thus, acquisition and production of a variety of parts of speech (e.g., verbs, nouns, adjectives) and grammatical morphemes (e.g., preset progressive /ing, plural /s, past tense /ed) unfolds (Brown, 1973). Consequently, the child's newly acquired rule-governed behavior then progresses into an extensive linguistic communication and expands to a matured use of communicative intentions (Wetherby et al., 1988; Wilcox & Shannon, 1998). For a summary of typical speech and language developmental benchmarks associated with the first three phases, see Table 1.

Documentation of developmental milestones, though important, masks a substantial amount of individual variability. The development of language and phonology does not occur in a definite predetermined or automatic manner, rather in an individualistic and overlapping way (Velleman, 1994). Although benchmarks may not predict what will develop next or what should be targeted for any particular child, Tager-Flusberg et al. (2009) suggested that they could be used to assess or monitor a child's development. Tager-Flusber et al. also recognized that many various childhood disorders might cause incongruities across the phases. For example, children with autism spectrum disorder (ASD) may be more advanced in phonological development (e.g., phase two) but may not have a strong use of vocabulary (e.g., phase one). Another example may be the reversal of the previous scenario for children with childhood apraxia of speech (CAS). Having reviewed milestones in typical development, the next section will consider potential causal influences related to difficulties in the production of the multisyllabic words/word combinations for various developmental disabilities.

Consideration of Causal Factors

The following section considers causal factors at the cognitive level that may contribute to breakdowns in children's development of multisyllabic speech productions. The production of speech is a complex phenomenon involving a variety of related cognitive processes that together are referred to here as the 'speech chain' (Denes & Pinson, 1993). Despite various theoretical orientations, the speech chain is commonly depicted with many of the same elements; Figure 1 displays the shared elements across models that are most relevant to the present study (see Hickok & Poeppel, 2007; Keyser & Stevens, 2006; Rapheal, Borden, Harris, 2007). Accordingly, the upcoming section will consider each element of Figure 1 in relation to children's speech-language production, particularly the production of multisyllabic words and phrases. However, it is important to note that breakdowns may occur in one or more levels of the speech chain and/or in the progression between the designated levels.

Speech Perception Disruption

Speech perception is an intricate process, described by Hickok and Poeppel (2007) as involving sublexical tasks, executive control, and working memory. Nittrouer (2002) also described this as the process by which a child retrieves the phonetic structure from a continuous acoustic signal. Thus, a disruption in speech perception may lead to an inability to attend to and/or perceive linguistic input as typically developing children do. Paul, Chawarska, Fowler, Cicchetti, and Volkmar (2007) conducted a study to test the hypothesis that failing to 'tune in' to natural language may ultimately contribute to the delays in communicative development for children with autism spectrum disorder (ASD). They studied auditory preferences in 52 toddlers with ASD and matched groups of (a) 44 typically developing age-matched children, (b) 32 age-matched children with developmental disabilities (not ASD), and (c) 30 typical-developing, younger children matched for language age. The researchers used the head-turn-preference procedure (HPP) to measure the participants' time spent attending to specific types of auditory stimuli: natural child-directed speech versus rotated speech (an unintelligible electronic manipulation of the child-directed (CD) speech. They found that their study supported the hypothesis they were testing: the children with ASD demonstrated reduced attention to the child-directed speech compared to all groups. The authors relate this finding to the deficits in language production associated with ASD.

A similar study conducted by Kuhl, Coffey-Corina, Padden, and Dawson (2005) implemented a 2 X 2 factorial design in which they compared auditory preferences in 29 children (between 32 and 52 months) with ASD to 29 typically-developing (TD) children. A head-turn procedure was used with the random presentation of eight samples of computerized, non-speech signal and eight samples of 'motherese' speech. Overall, the researchers found that the children with ASD as a group, when compared to typically-developing (TD) children preferred a computerized, non-speech signal and failed to show a preference to 'motherese' speech (see also Klin, 1991; 1992). Overall, the findings suggest that this failure to perceive speech may affect the child's ability to register when there is a speech signal present over environmental noises.

Focused on a different population, Groenen, Maassen, Crul, and Thoonen (1996) conducted a study using identification and discrimination tasks to examine the perception and production abilities of 17 children with childhood apraxia of speech (CAS) (mean age 8;9) and 16 control children. The children with CAS performed poorer on the discrimination task which involved comparing monosyllabic words that differed in place of articulation for the initial voiced stop consonants (e.g., /b/ vs. /d/). In addition, individual data assessed via cross-correlation analyses suggested a specific relationship between the auditory speech perception deficits and the frequency of place substitutions during production. In sum, data from both children with ASD and CAS suggest that speech-language deficits may result in part from difficulties in speech perception,

Cognitive-Linguistic Disruption and Phonological Representation Disruption

Within the given speech chain model, speech perception is followed by the cognitive abilities “to recognize, store, and retrieve input; to formulate rules for output, and to compare input and output” (Stoel-Gammon & Dunn, 1985, p. 74). Disruptions or differences in these cognitive processes are outlined in this section with an emphasis on semantic and syntactic forms.

Following the development of children's first words, Prizant (1983) proposed a gestalt vs. analytic framework to guide the interaction between the cognitive processing and linguistic development. That is, language development was purported to occur on a continuum between an “analytic” and a “gestalt” style of cognitive processing. The former refers to individuals who rely predominantly on single words until the linguistic rules for combining multiword utterances emerges. Such children would be predicted to progress in a relatively linear fashion through the semantic and syntactic milestones summarized in Table 1. In contrast, a gestalt style refers to children’s use of word combinations without explicit consideration or awareness of the meaning of individual words or the underlying syntactic structure, even if the utterances are used appropriately (Prizant, 1983). As a classic example, a child might use the phrase “What’s that?” to inquire about unfamiliar objects without the ability to use these three words separately in building other unique utterances.

Strong cognitive tendencies toward the gestalt have been associated with deficits in communication development. Children with autism spectrum disorders (ASD), for example, may rely heavily on gestalt processing in order to develop language (Brosnan, Scott, Fox, & Pye, 2004; Prizant, 1983; Roberts, 1989). This type of processing also typically co-occurs with comprehension deficits (Prizant, 1983). Consequently, it becomes difficult to comprehend and formulate novel utterances. Such individuals may use their memory to acquire language phrases in chunks, rather than parsing them into their specific linguistic units. This process of linguistic chunking, particularly when paired with unclear semantic referent or communicative intent, may account in part for the phenomenon of 'scripting' or echolalia often associated with children on the autism spectrum (Prizant, 1983).

It's possible that differences in cognitive processing styles relate to differences in working memory or learning capacities for children with ASD as well as other developmental disabilities, such as specific language impairment. Processing may be disrupted through a restriction on size of memory or workspace, limited energy to complete the cognitive task, insufficient time for processing, attention deficits, or inability to discriminate information. These processing limitations may be observed individually or in combination (Leonard, 1999; Weismer & Robertson, 2006). Limitations in processing capacity may lead to a number of speech, language, and/or attention impairments. However, most relevant to the present study, a disruption at this level of the speech chain will affect the connection to the remainder of the chain, thereby immediately affecting the phonological/linguist representation level and ultimately impairing the speech output (e.g., phonological representations, motor planning or execution).

Representations at phonological level provide a child with the ability to manipulate sounds distinctively and to compare his/her phonological differences to adult's language models

(Stoel-Gammon & Dunn, 1985). Breakdowns in the organization of language and sound systems may occur with a breakdown in phonological encoding. "Phonological encoding involves the simultaneous but separate retrieval of the segments (phonemes) and metrical frames (specifying the number of syllables and, for infrequent stress patterns, the stressed syllable), and the process of integration" (Robin, Maas, Sandberg, & Schmidt, 2007, p. 69). Disruptions in phonological encoding are likely to lead to developmental phonological processes (e.g., consonant cluster reduction) or specific articulation errors of substitution, distortion, addition, or omission.

Motor Planning Disruption

The production of speech is ultimately a motor act requiring the planning and programming of specific movements. A breakdown in motor planning may lead to an inability to voluntarily produce the movements required for the target speech output despite functional neuromusculature. The most commonly cited diagnosis related to a breakdown at the speech planning level is apraxia of speech, abbreviated as CAS during childhood (sometimes also referred to as dyspraxia, developmental verbal dyspraxia, DVD, developmental apraxia of speech, DAS). CAS is defined as "a neurological childhood (pediatric) speech sound disorder in which the precision and consistency of movements underlying speech are impaired in the absence of neuromuscular deficits (e.g., abnormal reflexes, abnormal tone)" (ASHA, 2007, p.1). According to a technical report by the American Speech-Language-Hearing Association (2007), CAS is characterized typically by highly inconsistent productions, severely unintelligible speech, groping during verbal productions, vowel distortions, difficulty transitioning from one articulatory place to the next, and frequent prosodic errors.

In addition to children with relatively isolated CAS, similar motor impairments have been documented in children with ASD. For example, Jones and Prior (1985) compared three groups of children on two non-speech, motor imitation tasks: (a) ten children with ASD, (b) ten age-matched children, and (c) ten typically-developing children matched to the mental age of the children with ASD. The authors examined the motor imitation skills of children with ASD to test for the "presence of soft signs of CNS dysfunction using a test battery that has proven useful in such assessment" (p.39). The motor imitation tasks that they performed were of a) simple hand movements and arm movements, b) dynamic body movements, and c) "soft signs" to test CNS function. The researchers concluded that the children with ASD had very poor performance on the motor imitation tasks relative to the other two groups. Also, they indicated that the poor performance on the motor tasks might be caused by a motor dyspraxia, due to the inability to imitate motor tasks and because of delayed typical developmental milestones.

In a similar, but much larger study, Dziuk, et al. (2007) discovered that even after adjusting for basic motor skill, a group of 47 children with ASD (mean age of 10 years and 7 months) displayed significantly worse praxis than the children without ASD. The children in the study completed: a) an assessment of basic motor skills for children and b) a praxis exam that required them to carryout gestures on command, through imitation, and with the use of tools. The authors suggested that additional information was needed to determine if the poor performance could be attributed to dyspraxia. However, the authors also proposed that dyspraxia may be a core feature of ASD due to the strong correlation that praxis displayed with the key behavioral, social, and communicative impairments associated with the disorder (see also Mirenda, 2008).

Motor Execution Disruption

Once a motor plan has been formulated, the desired speech output is dependent on explicit movements of numerous articulators. Disturbance at the level of motor execution is differentiated from motor planning by the observation of movements that are slow or weak, possibly unsteady and uncoordinated, and often with highly consistent errors (Love, 2000). Children with breakdowns at this level are often diagnosed as having childhood dysarthria. Love (2000) defined this as a "speech impairment caused by dysfunction of the motor control centers of the immature central and/or peripheral nervous systems and marked by disturbances of strength, speed, steadiness, coordination, precision, tone, and range of movement in the speech musculature" (p. 6). Dysarthria and CAS both present with motor impairments. Thus, it is important to be aware of the distinction between the underlying processes of each: CAS is a motor planning impairment and dysarthria is a motor execution impairment (see Strand & McCauley, 2008). Given this study's focus on children with ASD and/or CAS, disruptions due to dysarthria are not considered in additional detail.

Intervention Approaches

Having reviewed potential areas of disruption in the speech chain that might contribute to children's difficulties in producing multisyllabic utterances, the following section reviews available treatment approaches related to breakdowns in the areas most relevant to this study: disruptions in cognitive-linguistic processing and motor planning. In addition to treatment literature specific to these two areas of disruption, augmentative and alternative communication is addressed as a form of support for children with limited speech regardless of the specific causal mechanism.

Cognitive-Linguistic Processing

Treatment designed to target multisyllabic words in children with impaired linguistic phonological representations and/or the inability to access these representations should focus on linguistic units that extend beyond individual speech sounds. Although many different phonological interventions such as the Cycles Approach (Hodson & Paden, 1991) could be associated with the cognitive-linguistic perspective, the focus here will be on a couple studies that have focused explicitly on syllable combinations. An example, phonotactic therapy, is profiled by Velleman (2002) through use of a case study that targeted a new syllable shape rather than specific speech sounds. The presented rationale was that basic phonological frames need to be in place before shifting the focus to specific phonetic content. The case centered on a severely unintelligible 3-year-old boy whose speech repertoire included five consonants that were often distorted and limited to single-syllable utterances. Treatment was briefly described as focusing on two-syllable words and increasing the use of final consonants with speech sounds that were already in his repertoire. Specifics regarding strategies or techniques were not given. Six months after the onset of treatment, standardized assessment revealed that the child did not omit any syllables, but his intelligibility rating was still severe.

Consistent in part with approaches based on linguistic representations, Girolametto, Pearce, and Weitzman (1997) conducted a study that examined the indirect effects of lexical training on children's phonological abilities. The subjects included 25 toddlers (23-33 months old) who had expressive vocabulary delay, and were at the single-word stage of development. The children were either assigned to an experimental group or a control group that did not receive any intervention. The mothers' of the children in the experimental group were trained to provide "frequent, highly concentrated presentations of the target words without requiring responses" (p.338). Before and after intervention two measures of phonological diversity and one of accuracy were assessed. Results revealed that the toddlers who were in the experimental group made significantly greater gains than the toddlers in the control group in the two areas of phonological ability: syllable structure and consonant inventory. However, significant gains were not made in regard to accuracy of productions when compared to adult phonological models. Overall, this study supported the idea that acquisition of words can increase the variety of syllable structures and overall consonant inventory for children with limited speech output, although results have not been consistent across studies (see Robertson & Weismer, 1999 and Fey, Cleave, Ravida, Long, Dejmal, & Eaton, 1994).

Core vocabulary intervention is another linguistic-based approach that attempts to improve word productions' accuracy, consistency and intelligibly through treating whole words rather than individual sounds. McIntosh and Dodd (2008) reported three case studies that evaluated the effectiveness of core vocabulary intervention on three children, ages: 3;0, 3;9, and 4;2, with 'inconsistent phonological disorder.' The authors characterized inconsistent phonological disorder by frequent unpredictable uses of repeated productions (at the phoneme or syllable level). Due to the nature of the inconsistent phonological disorder, the goal of core vocabulary intervention was to initially establish consistent productions of words. Intervention was conducted twice weekly ranging from 12-38 total sessions depending on the child and focused on a minimum of 50 words that were reportedly already a part of the children's functional vocabularies. The words were not chosen or balanced by word shape or complexity. The key feature to this intervention involved the 'best consistent production.' This meant that the child was encouraged to say the word the same way each time, regardless if it was error-free or not. Thus, the first session aimed at determining the children's' best productions of the target words. The remainder of the sessions were used to 'drill' at least 20 productions of each word. Following intervention, formal phonological assessments revealed that all three children improved in their abilities to produce words consistently, accurately, and more intelligible (McIntosh & Dodd, 2008).

In sum, there is some reason to expect that targeting linguistic units larger than individual phonemes may be successful in increasing a child's use of varied phonological frames and repertoires (e.g., multisyllabic words, word combinations), albeit evidence is far from conclusive. Specifically, the phonotactic therapy and indirect lexical training studies reviewed here failed to demonstrate increases in child intelligibility; however, core vocabulary intervention focusing on consistent word usages succeeded in improving intelligibility of word productions but did not attempt to teach new expressive vocabulary.

Two strategies that are often incorporated in both motor learning and cognitive-linguistic approaches are the use of carrier phrases and exaggerated intonation patterns. Both strategies are viewed briefly here under the cognitive-linguistic approach because they focus on linguistic units larger than specific speech sounds. In regard to carrier phrases, familiar and potentially repetitive linguistic units (e.g., row, row, row your …), are thought to provide a degree of predictability and therefore, in turn, may reduce the information processing load of the communicative engagement (Yoder, Spruytenburg, Edwards, & Davies, 1995). Few if any studies have focused on their effect in isolation, particularly as they pertain to children's speech-language productions. However, the rationale behind their use is that they provide a shared history and a predictable opportunity for children to verbally participate, and they can capitalize on mental networks for semantic, syntactic, and prosodic priming (cf. DeThorne, Johnson, Walder, & Mahurin-Smith, 2009).

In addition to carrier phrases, exaggerated intonation is commonly used across various approaches in order to elicit both the frequency and accuracy of productions. The use of exaggerated intonation has been standardized in an approach referred to as Melodic Intonation Therapy (MIT), which has been applied frequently to adults with speech-language difficulties following neurological insult (Albert, Sparks, Helm, 1973; Sparks & Holland, 1976), however the precise mechanism for its proposed facilitation is often rather vague. Based on their review of the literature, DeThorne et al. (2009) proposed that modeling targets with exaggerated intonation may help recruit a somewhat different neurological substrate in the listener, particularly structures analogous to those used for linguistic processing but in the opposing hemisphere (Jeffries, Fritz, & Braun, 2003). In regard to evidence from the pediatric population, Wade (1996) compared the effectiveness of melodic intonation therapy (MIT) and an oral-motor treatment (OMT) on the production of initial consonants in a 3-year-old female with childhood apraxia of speech in a single-subject alternating-treatments design. At the onset of treatment, the subject had receptive language skills within normal limits, severely unintelligible speech with a limited phonetic repertoire, inconsistent speech errors, groping, and difficulty with sequencing phonemes. Thirty-minute treatment sessions were designated to 15 minutes of MIT and 15 minutes of OMT weekly for two months with a designated word set of increasing difficulty and differing target sounds assigned to each treatment condition. Melodic intonation was used to focus on three specific elements of prosody through exaggerating the intonation: stress, rhythm, and melodic line. The results indicated that both OMT and MIT contributed to the increase in initial consonant productions. However, MIT was significantly more effective than OMT at every word difficulty level. The researcher noted that the use of MIT allowed the child to focus on the melodic tone rather than the effortful and voluntary target sounds (Wade, 1996). Thus, the use of MIT had significant effects on improving this child's speech intelligibility (see also Helfrich-Miller, 1984; Krauss & Galloway, 1982).

Motor Planning

Whereas some approaches focus on larger linguistic representations, explicit deficits in motor planning might imply the need to focus on specific sounds and articulatory movements using documented principles of motor learning. Much of the literature on motor learning principles has studied movements other than speech, such as novel limb-learning tasks. However, recent attempts have been made to apply such findings to the motor demands of communication (e.g., Freedman, Maas, Caligiuri, Wulf, & Robin, 2007; Maas, Robin, Austermann Hula, Freedman, Wulf, Ballard, & Schmidt, 2008; Schmidt, & Bjork, 1992; etc.). Motor learning refers to the process of permanently changing the proficiency of skilled motor movements through behavioral intervention. It is measured by retention and transfer of skills (Maas et al., 2008). The text that follows will begin with a general summary of the principles of motor learning, followed by explicit consideration of the sparse number of speech interventions focused on motor learning.

Findings from the motor learning literature suggest that skill acquisition and generalization is strongly influenced by the structure of practice and the nature of feedback conditions (see Schmidt & Lee, 2005). These conditions can be broken down further into specific principles. Six conditions that relate to the structure of practice include: amount, distribution, variability, schedule, attentional focus, and target complexity (Maas et al., 2008). Small amounts of practice refer to a low count of sessions and/or trials when referencing the amount of time actually spent practicing the particular movement(s). Larger amounts of practice have been advised for greater skill transfer (Maas et al., 2008). Practice variability refers to whether treatment is focused on constant targets (e.g., one phoneme) or varied targets (e.g., phonemes in different contexts), with current recommendations focused on the latter (Maas et al., 2008). Target complexity can be viewed as simple (e.g., early acquired or CV syllables) versus complex (e.g., later acquired sounds or sound sequences), with simple target associated with faster skill acquisition and complex targets associated with greater generalization (Maas et al., 2008). In sum, present findings in the motor learning literature suggest larger amount of practice, variability of practice, and complex targets in order to best enhance learning and transfer of skills to meaningful contexts (See Baas, Strand, Elmer, & Barbaresi, 2008; Maas et al., 2008; Schmidt & Bjork, 1992; Strand, Stoeckel, & Baas, 2006; Wulf & Prinz, 2001).

The published intervention approach most closely aligned to the principles of motor learning is referred to as dynamic temporal and tactile cueing (DTTC), which has also been referred to as integral stimulation. A single-subject multiple baseline study by Strand, Stoeckel, and Baas (2006) utilized DTTC in the treatment of four children (ages 5;5-6;1) with CAS. Consistent with DTTC, intervention focused on the shaping of speech movements needed for specific target words, beginning with slow and simultaneous cueing practice. This approach requires children to take responsibility for generating their own motor plans by reducing visual, verbal, and auditory cues as the child progresses. Specifically in the study, feedback became delayed, less frequent, and focused on the movement rather than the ‘sounds’. Treatment sessions were frequent, with practice being distributed rather than massed. At the onset of treatment the children involved in the study all had severe CAS, extremely limited phonetic repertoires, and were nonverbal. Following treatment, results showed that DDTC therapy was effective for three out of the four children. Specifically, they developed approximately 8-12 functional utterances that were intelligible in six weeks compared to baseline data and in comparison to words that were not explicitly targeted (see also McCauley & Strand, 2008; Strand & Debertine, 2000; Strand & Skinder, 1999).

Though less directly tied to the principles of motor learning, another research approach, referred to as Prompts for Restructuring Oral Muscular Phonetic Targets (PROMPT), has utilized multimodal cues to facilitate speech production. The touch cues administered to the child's face and neck are intended to provide visual and tactile information regarding the manner and place of articulation. PROMPT was first developed for children with developmental motor speech disorders by Chumpelik (1984), but it has since been utilized for adult populations as well (see Bose, Square, Schlosser, & van Lieshout, 2001). In regard to the pediatric population, Houghton (2003) examined the effectiveness of PROMPT in five children, aging between 3 years and 9 months and 8 years, with severe persistent speech sound disorders through a series of single-subject case studies with multiple baseline measures on two behaviors. Data was measured with the Fisher-Logemann Test of Articulation Competence (Fisher & Logemann, 1971) and consonant accuracy in a spontaneous speech sample. Following baseline data collection, the subjects were assigned "four pairs of minimally contrasting phonemes, based on voicing; two pairs of phonemes for training PROMPT, and two as controls for probing imitation" (p. 22). Treatment consisted of a hierarchy of steps which included: auditory model with picture stimulus, use of 'surface' prompts, and then the child was asked to say the word as the SLP simultaneously provided a surface prompt per phoneme. Treatment included 10 trials per word until 80% accuracy was met for two consecutive sessions or a total of eight sessions were completed, which ever occurred first. Only two of the five children completed the treatment phase, due to the others not adhering to the protocol. For these two children, all trained phonemes had met at least 80% accuracy during the treatment phase. Untrained control phonemes did not show change for these two children, thereby suggesting changes in the target forms could be attributed to treatment. Although this study does present with limitations (e.g., three out of the five children were not measured), this study displayed hopeful outcomes with the use of tactile-kinesthetic input for at least some children with severe speech impairments.

Augmentative and Alternative Communication

Augmentative and alternative communication (AAC) has been used to support the communication of children who have difficulties in motor planning and/or cognitive-linguistic processing. Although the literature documenting the important roles of AAC is broad, the focus here is on the impact of AAC on speech production in particular. Related to this topic, Millar, Light, and Schlosser (2006) completed a comprehensive meta-analysis of literature spanning from 1975 to 2003. Six studies, which involved 27 cases, met the investigation's criteria for adequate experimental control. Across these studies, the participants' ages ranged from 2 to 60 years old and the majority had diagnoses of either mental retardation or ASD. In sum, the authors found that 89% of the cases exhibited increases in natural speech subsequent to AAC implementation, as measured primarily by number of words spoken. In addition, not one of the 27 cases displayed a decrease in speech production, although 11% demonstrated no change. Most of the studies reviewed in this meta-analysis implemented AAC intervention by means of nonelectronic aided systems or manual signs.

Gains in speech as a result from AAC intervention could be attributed to the fact that AAC allows one to bypass the strenuous linguistic or motor demands of voluntary speech production and concentrate directly on establishing key communicative skills (Millar et al., 2006; Romski & Sevcik, 1996). In addition, speech-output devices in particular can give children some control over what auditory models they hear and when, thereby increasing the likelihood that they will hear words modeled when they are meaningful to the child (DeThorne et al., 2009; see also Wulf, Raupach, & Pfeiffer, 2005).

Treatment research to date has appeared somewhat entrenched in unnecessary dualities such as a focus on either linguistic or motor approaches. Yet, research suggests that children's deficits are rarely isolated; for example, children with ASD demonstrate difficulties in both linguistic representation and motor praxis (Dziuk et al., 2007), and children with motor praxis may have difficulties with auditory comprehension (Groenen, Maassen, Crul, and Thoonen (1996). The present study intends to examine the effectiveness of a hybrid treatment approach designed to target potential deficits in motor planning and linguistic representation through treating a consistent target set both in motor practice and structured play. Specifically the study addresses the following question:

1. Does a hybrid treatment approach, incorporating strategies to facilitate both linguistic and motor learning, improve children's spontaneous productions of multisyllabic words/phrases?

CHAPTER II

Method

This study was a single subject multiple baseline design across target sets that served as a pilot for a larger group design study intended to compare the effectiveness of two forms of multimodal feedback (i.e., pacing board v. computer graphics). This pilot study included the pacing board for feedback purposes, but the computer graphics were not yet available. As is defining of within-subject methodology, each participant served as his/her own control across more than one condition. In this study, each child's production of different counterbalanced target sets provided experimental control (i.e., treated targets were compared to targets not yet treated; and all treatment targets were compared to the control targets that were never treated).

Participants

Three participants were recruited from the University of Illinois Speech and Language Pathology Clinic and are referred to throughout by the pseudo-names: Bryan, Evan, and Kelly. Each child met the following criteria: a) three to five years of age, b) expressive vocabulary of at least 50 single words, with fewer than five communicative word combinations based on parent report and observational data using the MacArthur-Bates Communicative Development Inventory: Words and Gestures (Fenson et al., 2006), c) a score below -1 standard deviation on the Goldman-Fristoe Test of Articulation-2 (Goldman & Fristoe, 2000) or observed oromotor and sequencing deficits on the Verbal Motor Production Assessment for Children (Hayden & Square, 1999), and d) typical hearing based on an audiological screening or prior evaluation. In addition to the inclusionary data, information regarding the children's cognitive functioning was gathered using the Ages and Stages Questionnaire (Squires & Bricker, 2009) with information regarding ethnicity and parental education level collected through a separate demographics questionnaire (see Appendix A). In cases where formal assessment data could not be collected, relevant skills were observed informally. A summary of descriptive data is offered in Table 2. All three children were receiving speech and language services elsewhere (either at school or another private setting) at the time of this study and none had been exposed to a speech-output augmentative and alternative communication device (AAC). It is important to note that Kelly and Bryan were siblings and were seen on the same days/time for the present study, albeit by different clinicians in separate rooms.

Procedures

Design

All three children received individual speech intervention focused on expressive use of multisyllabic targets. The 30 total targets (15 treatment and 15 control) varied for each child and were selected based on the following criteria: a) 2 or 3 syllables in length, b) within the children's receptive, but not expressive, vocabulary based on initial informal observations and parent report from the MacArthur-Bates CDI (2005), and c) composed of sounds from within the child's phonetic repertoire or alternatively, as phonetically simple as possible based on the *Index of Phonetic Complexity* (IPC; Jakielski, 2000). Related to this last criterion, all potential targets from the MacArthur-Based were rated using the *IPC*. The *IPC* is used to compute the complexity of speech sounds in a given word or utterance. Words and phrases were assigned a specific number of 'points' based on the following phonological features: place, manner, vowels, word shape, word length in syllables, place variegation, presence of clusters, and the cluster type (Jakielski, 2000).

The 30 multisyllabic targets for each child were assigned to one of two lists: 15 treatment targets and 15 control targets. The targets were balanced between the two lists as best as possible based on category (e.g., animals, verbs, house items, adjectives, etc.) and phonetic complexity (IPC). After the lists were balanced as best as possible, they were randomly assigned to represent either the control or treatment lists. Additionally, the list of treatment targets was subdivided into three sets of five targets to be treated one set at a time. The three sets of targets were also balanced by category and IPC rating as best as possible (see Appendix B, C, and D for examples). One of the three target sets was randomly selected for the initiation of treatment, with only one set targeted in any one session. The same target set was treated until mastery was achieved. Mastery for any particular target set was defined as accurate spontaneous productions of at least four of the five targets within a set, during play, and across two different sessions. The two different sessions were not required to be consecutive, and all four targets did not have to be produced in the same session. In other words, all but one of the five targets had to be used spontaneously by the child during at least two different treatment sessions. A child's individual target production was considered accurate if at least 50% of the phonemes were produced correctly and the appropriate number of syllables was marked verbally. For example, in scoring productions of the target 'teddy,' /tɛ/ (pronounced: teh) would be incorrect because only one syllable was marked, but /tɛ tɛ/ would be correct because both syllables were marked and 50% of the target phonemes were produced correctly. Insertions of extra syllables, three instead of the appropriate two (e.g., /kIk kIk kIk/ for /kIk It/), were marked incorrect. The same criterion for scoring accuracy was consistent across all forms of assessment. Following mastery of a set, a two-part probe procedure was completed (see below for details), followed by treatment on the next target set.

Intervention

Treatment was conducted at the UIUC Speech and Language Pathology Clinic. Each session was video-recorded using the clinic's closed-circuit monitoring system. Individual therapy sessions were conducted by one of two speech-language pathology graduate clinicians in the second year of their master's program. A University of Illinois faculty member, who is also an ASHA certified SLP with 15 years of clinical experience, served as the supervising clinician and participated in the treatment design and implementation as needed. The same graduate clinician saw Kelly and Evan, and a second, different graduate clinician saw Bryan. In addition, two undergraduate students in Speech and Hearing Science provided logistical assistance within treatment sessions as needed (e.g., holding the child in her lap or stabilizing the platform swing during play). Specifically, undergraduate assistance was provided consistently for Bryan and Kelly beginning on the 16th and 17th session respectively and continuing throughout the course of treatment. Assistance was provided with Evan for behavior management from session 7 to session 16.

Treatment sessions were approximately 45-minutes in length and scheduled up to three times weekly for a total of approximately 30 sessions. Bryan's course of treatment ended at the 27th session due to mastery of the third word set. Similarly, Evan mastered his final target set by the 25th session. For Kelly, treatment was discontinued after the 45th session, due to time constraints of the study and a failure to document consistent gains on the formalized assessments. For each child, one follow-up session was conducted approximately five weeks after the last treatment session to evaluate the maintenance of acquired skills. Due to time constraints for thesis deposit, Evan's maintenance session is not included in the present document because it had not been completed yet.

Aside from the two-part probe procedures, which are described shortly, treatment sessions consisted of a motor practice period followed by structured play activities. Both portions of the session were designed to incorporate principles from the motor learning literature that have been shown to enhance motor skill development and transfer of skills to meaningful contexts (Maas et al., 2008; see also Freedman et al., 2007; Robin et al., 2007; Schmidt & Bjork, 1992; Strand et al., 2006). Specifically, treatment sessions were held frequently with a focus on maximizing use of the treatment targets in a variety of meaningful contexts (see Appendix E for details). Additionally, when a target was too difficult for the child, a simplified model consistent with the child's phonetic repertoire was provided by the clinician. For example, when the target word 'paper' was not elicited from Evan using the traditional pronunciation, it was modeled as /peɪ peɪ / (pronounced 'paypay') given his demonstrated success with reduplicated syllables. When the simplified word was elicited successfully from the child, the clinician would reiterate the full model again: 'That's right, paper." Consistent with work by Dodd and colleagues, the phonologically simplified model was provided in order to elicit the child's best possible production, even if that production included developmental errors (Crosbie, Holm, & Dodd, 2005; Dodd & Bradford, 2000). An additional technique to elicit and shape productions included the use of visual-tactile cues implemented on the child or clinician's face and neck in order to provide information on place and manner of articulation. Such cues were similar but not identical to cues utilized through PROMPT (Bose et al., 2001; Chumpelik, 1984; Houghton, 2003); see Appendix F for a complete list of specific visual and tactile cues used for individual phonemes within the present study.

Motor practice. Treatment sessions began with a period of motor practice using a pacing board that consisted of 2-3 colored circles adhered with velcro to a cardboard strip (see

Appendix G). The clinician referred to the pacing board as the 'talking board' and modeled each target five times using exaggerated intonation. Consistent with traditional use of a pacing board (Kumin, 1995; Velleman, 1994), the clinician simultaneously tapped a different circle for each syllable as it was being said. After each model, the clinician prompted the child with "You say it' as needed in an attempt to elicit imitation. If the child did not respond, the clinician facilitated hand-over-hand tapping of each circle while restating the target; see Appendix H for motor practice procedures. A visual strip with a picture of each target depicted five times was presented in conjunction with the pacing board, thereby representing the number of repetitions the child was expected to produce. After each attempted repetition, the clinician, or in some cases the child, crossed off one of the pictures. Motor practice was anticipated to take approximately 10 minutes to complete once the child become familiar with the task, but in truth, it varied largely based on the child and the individual session.

Modifications to the motor practice procedure were made based on each child's needs. For example, in attempts to foster Kelly's symbolic understanding of the words and objects, real pictures were paired with the symbolic Boardmaker pictures on the motor practice strip and on the GoTalk beginning with the 17th session (see Appendix I). Additionally in an effort to regain Kelly's attention and participation during motor practice, in sessions 22 through 28, the clinician varied the presentation of the provided model: a quiet, whispered-like model was given followed by a model with exaggerated intonation and regular volume. Following session 28, a whispered or louder model was only presented as needed to regain Kelly's focus to the task at hand.

Also, real objects were introduced during motor practice as the target was being practiced (e.g., a toy giraffe was used to tap the circles when 'giraffe' was practiced); this modification was implemented beginning with the 19^{th} session. Similarly for Evan, real objects and meaningful activities were integrated to make motor practice more engaging (e.g., when practicing 'paper,' the clinician modeled the target while tapping and drawing on two pieces of paper). In all cases, motor practice offered an explicit opportunity to practice each target 5 times with visual and tactile feedback facilitated by the clinician.

Structured play. Following motor practice, the clinician attempted to engage each child in a variety of structured play activities designed to model and elicit the five treatment targets being facilitated that session. Sample activities included playing 'I'm gonna get you' with a teddy bear, blowing bubbles, drawing, and playing with animals in a tub of water. Specific treatment strategies drawn from the developmental literature included: emphasizing the targets within playful and repetitive routines (Sorensen & Fey, 1992; Yoder, Spruytenburg, Edwards, & Davies, 1995), using exaggerated intonation (Kouri & Winn, 2006; Wade, 1996), providing visual referents through objects, pictures, and the Go Talk 20+ (DeThorne, Johnson, Walder, & Mahurin-Smith, 2009; Millar et al., 2006), and prompting the child through time-delayed initiations (Halle, Marshall, & Spradlin, 1979), forced choices, cloze tasks, open-ended questioning, modeling (Goldstein, 1984; Leonard, 1975) and imitation (Ezell & Goldstein, 1989; Schwartz, & Leonard, 1985).

The number of elicitations and models from the clinician was roughly controlled across targets and across sessions. This was done by the clinician re-watching each session and filling out a data sheet regarding her use of each strategy (see Appendix J). If one or two targets had a significantly greater amount of elicitations/models than the other targets, the next session was adjusted to compensate for the targets that were lacking in elicitations/models. However, the number of models generally varied across sessions and across child (e.g., Kelly required more models because she did not use the targets independently as Bryan and Evan did).

Data from Treatment Sessions

Percent accuracy for correct imitations of the targets was measured during the motor practice portion of each treatment session in order to monitor the children's performance during that specific portion of the intervention. The accuracy was calculated by dividing the number of correct imitations the child produced by the total number of opportunities to produce them (usually 25 opportunities: five targets, each modeled five times). During the structured play portion of the sessions, the percent of the five treatment targets accurately produced imitatively and spontaneously was measured (# out of five targets). Again, productions, whether spontaneous or imitative, were only considered correct if at least 50% of the phonemes were produced accurately and all syllables were vocally marked. All probe and treatment data were displayed in graphic form for visual inspection of changes in level, trend, and latency based on data evaluation in single-subject design (Kazdin, 1982).

Assessment

Two-Part Treatment Probes

Once a child reached mastery for a particular target-set, defined previously as at least 4 treatment targets produced accurately in more than one session (not necessarily consecutive sessions), a two-part probe procedure was conducted before introducing a new target set to treatment. The first part of the probe consisted of a card-labeling task that included all 15 treatment targets intermixed across sets. Each target word was represented by the same Boardmaker symbol as included on the child's GoTalk during treatment sessions and was individually shown to the child with the prompt "What's this?" If the child did not produce a spontaneous label within five seconds of the prompt, the clinician prompted an imitation: "This is a ____ (e.g., giraffe); you say ____ (e.g., giraffe)". If the child failed to repeat the target, the

Go Talk 20+ was presented, and the child was asked to “show me ____ (e.g., giraffe)”. If needed, hand-over-hand selection of the target on the GoTalk was implemented. The procedure was designed so that the child would be able to produce each of the target items with the least degree of support needed (see Appendix K for a diagram of the entire probe procedure). Only spontaneous productions were utilized as a dependent variable with percent accuracy based on the number of targets produced correctly.

The second part of the probe, referred to as the ‘box task,’ was intended to provide an opportunity for spontaneous use of each of the 15 treatment targets in a more naturalistic context that mirrored the structured play during treatment. Specifically, items that represented each target were enclosed within a transparent plastic box. The clinician introduced the box by saying, “Here are some toys for us.” The toys were the same as those used during treatment itself. Approximately 5-10 seconds after introducing the box the clinician opened it. The delay in opening the box was intended to elicit the word ‘open’ from those children for whom it was a target. After opening the box, the clinician waited another 5-10 seconds for the child to initiate an interaction with any of the objects. If the child selected a toy, he or she was given approximately 30 seconds to play with it before the clinician put it away and waited for the child to initiate an interaction with a different object. If the child did not produce the target form for the object within 5-10 seconds of it being taken from the box, the clinician would prompt the child to provide a label through use of a carrier phrase: either “You want a ____?” for a noun, “You want to ____” for a verb, or “It is _____” for an adjective. If the child did not choose an object from the box, the clinician would present an object to the child with a carrier as needed, until all 15 targets were highlighted. The clinician did not introduce the label for any of the targets unless the child produced it first.

An additional 'modified' two-part probe was conducted for Kelly between sessions 33 and 34, in attempts to mirror her gains made during treatment sessions. The same procedures were followed as the standard two-part probe, with the exception to the way the clinician's model was given. Specifically, the card-labeling task was modified to elicit imitations by alternating the clinician's model of target forms between a whispered voice and a normal volume with exaggerated intonation. The box task was also modified by incorporating carrier phrases that Kelly was familiar with, such as 'here comes the *giraffe'* or 'I like *candy*.'

Pre-, Mid-, Post Treatment, and Maintenance Card-Labeling Assessments

A four-step assessment procedure that mirrored the card-labeling task from the probes was conducted for all 30 targets (15 treatment and 15 control) at four specific time points: a) pre-treatment, b) mid-treatment, c) immediately post-treatment and d) a maintenance assessment performed approximately five weeks after the completion of treatment. The task was introduced as follows: "We're going to help teach Mr. Pony some words today. What is this?" as the clinician held up a picture of a ____. Thus, like the probe task, the first step of the assessment involved the child being shown a Boardmaker symbol for each word. In contrast to the probe, the assessment included all 30-target words (i.e., 15 treatment & 15 control) in order to assess the specificity of treatment effects. The second and third steps of the assessment mirrored the card-labeling probe with attempts to elicit imitation and Go Talk selection as needed. In the probe task and throughout treatment sessions, the 15 treatment targets were available on a single overlay; however, the assessment of all 30 targets required them to be dispersed across two separate Go Talk overlays, since one overlay only accommodated 25 symbols. Consequently, the treatment and control targets were deliberately dispersed across the two overlays such that the treatment targets maintained the same position on the overlays as they held during treatment. Thus, one overlay contained seven treatment targets and eight control targets; the second overlay contained 8 treatment and seven control targets. In other words, if the target 'happy' were located on the lower right corner of the GoTalk overlay during treatment, then the symbol for 'happy' would be located in that same position on one of the assessment overlays (see Appendix L). Such consistency in placement across treatment and assessment was meant to accommodate the motor-learning involved in AAC use. Given that two overlays were required for the assessment task, the overlays were switched at the mid-point of the activity. Throughout the assessment, the control and treatment targets were intermixed and presented at a random order.

Despite the multi-step nature of the assessment task, only unprompted, correct productions were coded as correct across the assessments. When all targets were initially selected, the children were reportedly not using them; therefore, a spontaneous opportunity in the pre-treatment assessment for Bryan and Kelly was not explicitly included. Consequently, only the percent accuracy for direct imitations was measured (# correctly imitated out of 30 targets) at this initial time point. An explicit opportunity for spontaneous productions was added at the mid-treatment time point for Kelly and Bryan in attempt to further strengthen the design. As mentioned previously, correct responses required a minimum of 50% of the phonemes produced correctly paired with accurate marking of all syllables.

Reliability

The clinicians who provided the intervention derived all data for the present study through on-line recording and review of video recordings taken for each session. To help ensure valid measurement, inter-rater agreements were calculated for approximately 10% of the treatment sessions and for all of the probes and assessments for each child by a senior in Speech and Hearing Science who was naïve to the specific details of the study. In general, agreement was derived for each of the key dependent variables by dividing the number of agreements by the total number of potential agreements, multiplied by 100. As an example, the total number of potential agreements for the spontaneous production of target words within an individual treatment session is five, which becomes the denominator. The numerator would consist of the number of those five words that both the clinician and the reliability rater heard produced correctly by the child in that particular session. Mean agreement for the spontaneous productions from 10% of the treatment sessions for each child ranged from 86.7% to 92%. Agreement for children's spontaneous productions during the probe procedures ranged from 86.7% to 100%, whereas agreement across all three children for the card-labeling assessments ranged between 90% and 100%. See Table 3 for the agreement percentages for each child and task respectively. Note, Evan's reliability data were not included in the present document because it had not been calculated yet.

CHAPTER III

Results

Consistent with single-subject methodology, results were visually analyzed per individual child. Analyses to address the primary research question of treatment effect were two-fold. First, analyses relied on a visual inspection of production accuracies during the two-part treatment probes on multisyllabic targets that had been treated versus those that had yet to be treated (i.e., vertical comparison across panels). A second form of control consisted of a comparison of the child's percent accuracy for treated versus control targets on the pre-treatment, mid-treatment, post-treatment, and maintenance card-labeling assessments. After orienting the reader to relevant graphs, each child's results will be discussed in regard to these two primary analyses. Additionally, a third analysis was completed for Kelly regarding the results of a modified two-part probe procedure.

Orientation to Figures

Figures 2, 3, and 4 illustrate the participants' progress across all three treated target sets throughout the course of treatment as well as their performance on the two-part probe procedures that occurred after each target set was mastered. The x-axis represents the session number and the y-axis designates the percentage of the targets in that particular set that was produced correctly under various conditions. Except for motor practice, the percent correct was out of five targets in all the tasks/conditions, and represented how many of the five targets were produced correctly in a given session. The total number of times each target was used (e.g., total tokens) was not measured. For example, if a child spontaneously used two out of the five targets, with the correct phoneme and syllable-marking accurately, at least once in a single session, that would be represented as 40% accuracy, regardless of how many times those targets were used. On the other hand, the percent accuracy for motor practice was out of 25 total opportunities due to each target being intentionally elicited five times (5 targets x 5 opportunities = 25). Only the children's performance on the spontaneous productions during play served as the determinant of mastery for each target set- as it was deemed the most desirable and naturalistic outcome.

It is also important to note that, due to the criterion for mastery of a set, a downward turn in the graph can occur as the set is mastered. Recall that the criterion for target set mastery was defined as spontaneous production of at least four of the five targets in at least two different sessions. Those sessions were not required to be consecutive, and all targets were not required to be used in the same session. As an example, refer to Bryan's spontaneous productions of the second target set as displayed in the middle panel of Figure 2. Bryan's productions led to a positive trend from 0% accuracy in session 16 to 100% accuracy in session 21 (i.e., all five targets were used spontaneously in that session); however, on the 22nd session, his performance dipped to 40% accuracy (two targets used spontaneously). Despite the downward dip at session 22, Bryan still met mastery criteria for the target set because he only needed a spontaneous production from one of the targets (three of the other targets had already been used spontaneously in two other sessions).

Figures 5, 6, and 7 compare each child's production accuracy on all treatment targets versus control targets during the pre-, mid-, post-, and maintenance card-labeling assessments. As described in detail previously, this task involved labeling 30 picture cards. The percent accuracy represents the number of targets produced correctly by the child out of 15, either the 15 treated targets or the 15 control targets. Note that the mid-treatment assessment occurred on the 16th treatment session, which corresponded to the second treatment phase for all three children. In other words, at the mid-assessment point, mastery of the first target set had been achieved and treatment of the second target set had begun. The assessment results for Bryan, Evan, and Kelly are depicted in Figures 5, 6, and 7 respectively.

Bryan

Turning to data for Bryan specifically, the effectiveness of treatment was supported by a generally positive trend in the dependent variables during treatment phases for each of the three target sets (see Figure 2). Additionally, for each of these target sets, the baseline assessment data and the first treatment session within each set were at lower accuracy levels than performance during the final treatment session within a set and the probe that followed. For example, Bryan began the first target set with 0% accuracy during the baseline imitation task and spontaneously produced 0% of the targets in the first treatment session. However, at the close of the first treatment phase, Bryan produced 3 of the 5 targets within each of the last three sessions and achieved 80% and 100% on the box and card labeling tasks respectively. Despite differences in the specific beginning and final accuracies achieved, similar positive trends were noted during the second and third treatment phases as well. Also interesting to note was the rate at which each target set was mastered. Bryan required fewer sessions in order to meet mastery criteria as intervention progressed. The first target set was mastered in 10 sessions, the second in 9 sessions, and the third in 4 sessions. Although data on individual target sets speak to progress in target production over time, such values do not specify the extent to which progress is due to treatment rather than general development or other ‘confounding’ factors.

Vertical Comparison of Treatment Probes

To specify treatment effects, readers are referred to the change in percent accuracy of a target set compared to change in an untreated target set during the same time period, in other words, inspect the panels in Figure 2 vertically. Note that when referring here to targets as untreated, it means that they have yet to be treated but are still part of the 15 treatment targets (as opposed to the 15 designated control targets). For example, Bryan increased his percent accuracy from 0% in the baseline imitation procedure to 80% and 100% during the box task and card labeling probes conducted at the close of the first treatment phase. In contrast, Bryan's accuracy on the untreated target sets only increased from 0% to 20% on both the box and card-labeling tasks. A similar, albeit less straightforward, effect was seen when comparing gains in the second target set to gains in the third target set before and after the second phase of intervention. Specifically, Bryan increased his probe performance on the second target set from 20% to 80% on both the box and the card-labeling tasks. In comparison, gains in the third target set that had not been explicitly treated yet, remained at a steady 20% for the box task but increased from 20% to 80% in the card-labeling task. Reasons for the increase in card-labeling task will be considered in the discussion. However, it is important to note here that all treatment words (even if they were not yet targeted in intervention) were available to Bryan on the Go Talk20+ from the first treatment session; additionally, the symbols on the AAC device were the same ones used during the card-labeling task.

Pre-, Mid-, Post Treatment Card-Labeling Assessments

The second primary means of addressing the treatment effect for Bryan is to compare his performance on the card-labeling task for the 15 treatment targets to the 15 control targets across pre-, mid-, post-treatment, and maintenance assessments. Bryan's data, displayed in Figure 5, showed a substantial increase for the treatment targets (0% to 60% to 100% to 93%) compared to the change in control targets (0% to 0% to 20% to 13%). All values in Figure 5 represent percent accuracy of spontaneous productions on a card-labeling task except for Bryan's baseline point in which spontaneous productions were not specifically elicited. Consequently, the baseline accuracy represents imitation accuracy only. Remember that the scored targets only included those that met the criteria of both syllables marked and 50% of the phonemes produced verbally accurate; for a comparison of the overall percentage of attempted targets to the accuracy percentages see Appendix M. During the mid-treatment assessment point, Bryan spontaneously labeled four targets from each the first and second sets and one target from the third set. During the post-treatment assessment, Bryan labeled three of the control words (hammer, happy, and bunny). It is worth noting that two of these words, *hammer* and *happy*, were treatment words for his sister, Kelly. Interestingly, Bryan would come into Kelly's therapy room, either before or after the treatment sessions, and select these words, along with others, on Kelly's Go Talk20+. During the maintenance assessment, Bryan labeled two of the control targets: *candy* and *happy*. Again, these were words that Bryan independently accessed on his sister's Go Talk20+ before and after intervention sessions.

Evan

Turning now to Evan, the 3-year-old child with documented motor-planning issues without the diagnostic features of autism, a generally positive trend across dependent variables was also observed across individual treatment phases (see Figure 3). As seen with Bryan's performance, each of the target sets' baselines and initial treatment session were associated with lower accuracy levels than the final treatment sessions for individual sets and in comparison to the accuracy demonstrated during the post treatment assessments. For example, Evan began the first target set with 0% accuracy in spontaneous production of the targets during baseline tasks, and he spontaneously produced 20% of the targets in the first treatment session. However, at the close of the first treatment phase, Evan produced 4 of the 5 targets within the last treatment session and achieved 80% and 40% on the box and card labeling tasks respectively. Similar positive trends were noted during the second and third treatment phases. The number of sessions needed to reach the mastery criterion varied somewhat for each target set. The first target set was mastered in 7 sessions, the second in 9 sessions, and the third in 6 sessions.

Vertical Comparison of Treatment Probes

Turning now to experimental support for treatment effects, Evan's performance mirrored the general treatment effect observed across target sets for Bryan but with clearer results. Specifically, Evan increased his percent accuracy from 0% on both the card and box tasks in baseline, to 40% on the card task and 80% on the box task during probes conducted at the end of the first treatment phase. In contrast, Evan's accuracy on the untreated target sets remained at 0% for both tasks at the completion of the first treatment phase. Similarly, at the close of the second treatment phase, Evan had increased his probe performance on the second target set from 0% to 60% accuracy on both the box and card labeling tasks while gains in the third target set (not yet explicitly treated) remained at 0% for the card task and crept up to 20% in the box task.

Of interest, in addition to the gains in the second and third target sets, the first target set also increased from 80% to 100% on the box task, and from 40% to 80% on the card task. Specifically, Evan's productions of *kick it* and *pony* (from the first target set) were being produced with greater phonetic accuracy than during the earlier probes. Evan had attempted both targets in first probe (following the first intervention phase), but his productions of them had not met accuracy criteria (i.e., *kick it* was produced as /kIk kIk kIk/). Note, specific treatment on these words (motor practice and explicit play activities) was discontinued after the first treatment phase, but this obviously did not preclude Evan from selecting these words on the Go Talk20+ during the sessions, saying them during treatment, or producing them in other settings.

Pre-, Mid-, Post Treatment Card-Labeling Assessments

All assessments with Evan, including baseline, measured the percentage accuracy of his spontaneous productions on the card-labeling task, and they are displayed in Figure 6. Evan's performance on the card-labeling task for the 15 treatment targets and the 15 control targets across pre-, mid-, and post-treatment assessments showed a notable increase for the treatment targets (0% to 27% to 53%) compared to the lack of change in the control targets (0% to 0% to 0%). Note, the scored targets only included those that met the criteria of both syllables marked and 50% of the phonemes produced verbally accurate were; for a comparison of the overall percentage of attempted targets to the accuracy percentages see Appendix N.

It is important to note that the mid-treatment assessment took place on session 16; at this point Evan had explicitly received six treatment sessions on the second target set. During the mid-treatment assessment, Evan spontaneously labeled three targets from the first set (*kick it*, *pony*, *oven*) and one target from the second set (*happy*). During the post-treatment assessment Evan labeled three targets from the first set (*kick it*, *oven*, *table*), three targets from the second set (*paper*, *zipper*, *happy*), and two targets from the third set (*under* and *people*).

Kelly

Kelly, Bryan's younger sister and the only child without a diagnosis of apraxia, demonstrated the least convincing evidence of treatment effectiveness overall despite generally positive trends in the dependent variables within individual treatment phases (see Figure 4). For example, Kelly began the first target set with 0% accuracy during the baseline imitation task and spontaneously produced 0% of the targets in the first three treatment sessions. However, at the close of the first treatment phase, Kelly produced 2 of the 5 targets for three of the last four sessions. Similar positive trends were noted during the second and third treatment phases. In the second treatment phase, Kelly had a generally positive trend from 0% of the targets produced spontaneously in the 22nd treatment session to 80% of the targets produced spontaneously in the 32nd session (refer to Figure 4). The third treatment phase had a less substantial, yet still positive trend, despite the downward dip on the 44th session, starting with 0% accuracy in session 34 and ending with 40% accuracy in session 45. In relation to the rate at which the treatment sets were met, Kelly required 19 sessions to meet mastery criteria for the first target set, 11 sessions for the second, and treatment was discontinued after 12 treatment sessions on the third set due to the study's time constraints; therefore, the third target set never met mastery criterion.

Vertical Comparison of Treatment Probes

Although data during the course of individual treatment phases suggested progress in target production over time, such gains were not replicated in the experimental context of the probe and assessment tasks. In fact, Kelly's percent accuracy for all target sets remained at 0% from baseline and throughout all probe procedures, both card labeling and box tasks, conducted at the close of all individual treatment phases. In Kelly's case, the 0% accuracy reflected a lack of attempts at the targets rather than misarticulated attempts. Despite Kelly's lack of improvement in percent accuracy during probes, she remained engaged for both the card labeling and the box tasks. Kelly would make appropriate eye contact (e.g., when she wanted the box open, she would look at the clinician after attempting to open it herself), attend to or even play with the objects, verbally say 'all done' when she was ready for a new object, and without prompting, she put away objects after use.

It was the investigators' impression that the mismatch between Kelly's performance in treatment versus the probe procedures represented her heavy reliance on the clinician's modeling and prompting during treatment sessions, a form of support which was not present within the probing procedures. For example during treatment, the target *giraffe* was introduced during a tickle game, in which the following carrier phrase was used with exaggerated intonation on the word *giraffe*: "here comes the *giraffe*, tickle tickle." After modeling the phrase and performing the social game, the clinician would then start the phrase "here comes the _____" and pause. Kelly would often complete the phrase by saying *giraffe*. Additionally, after the routine had been practiced, Kelly would provide the whole phrase herself; however, she would not request the routine by stating only *giraffe* without the carrier phrase. Within treatment sessions, such productions were counted as spontaneous if the word *giraffe* had not been used by the clinician in the five seconds prior to Kelly's production. The standard administration of probe and assessment procedures did not include the specific carrier phrases that Kelly had come to associate with the target.

Modified Probe Procedures

Due to the examiner's hypothesis that Kelly's lack of attempted targets during probe procedures represented a reliance on the verbal prompting provided in the course of treatment, an additional and modified two-part probe procedure was administered between sessions 33 and 34. Specifically, the card-labeling task was modified to elicit imitations by alternating the clinician's model of target forms between a whispered voice and a normal volume with exaggerated intonation. With this modified presentation of models with varied intonation, Kelly imitated 80% (12/15) of the treatment targets during the card-labeling task. This accuracy represented a stark contrast to the 0% imitated during the standardized presentation. The box task was also modified by incorporating carrier phrases that Kelly was familiar with, such as 'here comes the *giraffe'* or 'if you're *happy* and you know it…' When familiar carrier phrases were employed, Kelly's probe performance increased to 27% (4 of the 15 treatment targets) during the modified box task.

Of interest, all four target words that Kelly produced during the modified box task were from the second set, which had most recently received treatment. Additionally, a reversal in performance was observed on the succeeding standard-probe, which was completed on the 46th session (refer to Table 4).

Pre-, Mid-, Post Treatment Card-Labeling Assessments

Kelly's performance on the standard pre, mid, post, and maintenance assessment, as displayed in Figure 7, mirrored her performance on the standard two-part treatment probes. At the baseline assessment, Kelly imitated 6% (one target) of the control targets and 0% of the treatment targets. Remember, baseline was only conducted in imitation; there was no explicit opportunity for spontaneous productions. Kelly's performance across mid-, post-treatment, and maintenance assessments on the 15 treatment targets compared to the 15 control targets did not differ: all remained at 0% accuracy.

CHAPTER IV

Discussion

Primary Findings

The purpose of this study was to determine if the implementation of a hybrid treatment approach, incorporating linguistic and motor learning strategies, would improve children's spontaneous productions of multisyllabic targets. Results indicated that gains in multisyllabic productions could be attributed to treatment for two of the three children. Specifically, both Bryan and Evan produced gains in the treated target sets relative to those that had not yet been treated. In addition, gains in the treated targets as a whole exceeded gains in the control targets that were never explicitly treated. Although Kelly did not demonstrate a treatment effect through the probes and assessments, she did produce many of the target forms during the actual treatment phases, reaching mastery on two of the three target sets. The ensuing discussion will focus on a (a) comparison of treatment effects to findings in prior literature, (b) reflection on which aspects of the treatment were useful for specific children, (c) consideration of why effects were not apparent for Kelly, and (c) a review of study limitations.

Comparison of Treatment Effects to Prior Literature

A unique aspect of the present study was the simultaneous focus on facilitating production of both new words and also a new phonological form. Previous studies involving toddlers with delayed (or poor) speech development that have focused on linguistic units such as words, phonological frames and grammatical structures have demonstrated limited effects on overall intelligibility in regards to the accuracy of productions when compared to adult models (Girolametto, Pearce, & Weitzman, 1997; Robertson & Weismer, 1999; Tyler & Sandoval, 1994; Velleman, 2002). On the other hand, studies that have addressed motor planning breakdowns, specifically by applying principles of motor learning, have been successful at producing long-term effects on the intelligibility of words/phrases that were explicitly treated during intervention, but with relatively limited evidence of generalizability to new forms or naturalistic contexts (Bose, Square, Schlosser, & Lieshout, 2001; Houghton, 2003; McCauley & Strand, 2008; Strand & Debertine, 2000; Strand & Skinder, 1999; Stand, Stoeckel, & Bass, 2006). The present study offered evidence that a hybrid approach could successfully elicit new vocabulary words and improved accuracy of a new phonological form (i.e., multisyllabic productions). In addition, gains were noted within the context of a card-labeling task as well as the more naturalistic context of the box task, which attempted to mimic structured play.

Similar to findings from Strand, Stoeckel, and Baas (2006), gains from the present study showed limited generalization to other selected stimuli of comparable complexity (see also Strand & Debertine, 2000). In fact, demonstration of experimental control was contingent on this fact given the multiple baseline design across target sets. This study's design relied on the acquisition of treated targets contrasted to the absence of a gain on the control targets in order to display a treatment effect. Despite this fact, there were hints that Bryan and Evan's gains may have begun to generalize to untreated targets. Specifically, Evan spontaneously used the word 'balloon' from the third target set during the box task prior to explicit treatment of the word (see Figure 3). Similarly, Bryan spontaneously labeled four of the five targets from set three in the card task before they were treated, although he did not produce them in the less structured box task prior to treatment (see Figure 2). Bryan demonstrated acquisition of 4 of the control words prior to study completion. Finally, it is worth noting that both Bryan and Evan were informally observed by the clinician to use an increasing number of multisyllabic utterances and improved articulation by the end of the study. Similar observations were reported by both boys' mothers and by their school personnel. Although encouraging in terms of overall progress, the present study cannot determine the extent to which such reported gains were due to generalized effects of the treatment, overall maturation, or some combination of these and other tertiary factors.

Given the promising treatment effect achieved in the present study, a brief note is warranted in regard to the length of treatment in comparison to other studies focused on increasing the use of multisyllabic words or word combinations. Bryan and Evan's gains were attained through a total of 27 and 25 treatment sessions over the course of four to six months. For comparison, Velleman's 2002 case study focused on the use 'phonotactic therapy' for a three-year-old child with severe unintelligibility. The treatment consisted of two sessions a week over a six-month time period, presumably for a total of 32 sessions. Despite reported gains in productions of two-syllable words, the child's intelligibility rating remained 'severe' at the close of the study. In addition, the intervention study by Strand, Stoeckel, and Baas (2006) utilized motor learning principles with three children diagnosed with childhood apraxia of speech (CAS) for two sessions per day, five days a week for six weeks (a total of 43-50 sessions), and targeting approximately 8-12 functional utterances. Although comparisons of treatment effects across studies are difficult to interpret due to the numerous differences between them, results suggest that the present study offered promising gains within a course of intervention comparable in length to other studies.

Aspects of the Treatment Deemed Useful

This hybrid approach was designed to assess the general effectiveness of linguistic and motor learning techniques combined; therefore, evaluating the independent effects of these individual components was not possible. However, observational data emerged in support of three particular strategies that might prove useful in shaping future work: specifically, integrating a speech-output device within communicative interactions, utilizing varied intonation to elicit imitation, and embedding functional carrier phrases within playful communicative routines.

Speech-Output Device

In order to facilitate the multimodal nature of communication and to prioritize the primary goal of communicative success, all children were given access to a Go Talk20+ throughout the structured play portion of intervention sessions. The overlay included all 15 target words for the study as well as a few additional words and phrases that the clinicians felt would help facilitate interactions (e.g., 'I need help.' and 'Your turn'). In addition to providing access to the device, the clinician often modeled communicative productions on the device consistent with the strategy of aided stimulation (Romski & Sevcik, 2003). Within treatment sessions, Bryan and Evan frequently made unprompted use of the Go Talk20+ for communicative interactions, primarily requesting. For example, Evan and the clinician would often take turns coloring or drawing during the structured play portion of sessions. When she would ask him to take a turn, Evan would shake his head no, select 'your turn' on the GoTalk, and point directly at the clinician. Particularly of interest in regard to facilitating speech, Evan often verbalized 'your turn' (pronounced 'uhtuh') after selecting it on the device. In addition, Evan would often turn to his GoTalk when the clinician was trying to elicit a target word that seemed particularly difficult for him to say, like *zipper.* In some cases, Evan would actually attempt the target, saying 'uhdit' for *zipper*, then select it on the GoTalk, followed by another attempted imitation which was often improved in pronunciation to the first attempt: 'uhper.'

Bryan made even more frequent use of the GoTalk within sessions than Evan and seemed to show a similar pattern of facilitated verbalization. Despite never having had access to a speech-output device, Bryan began selecting a favored item (i.e., *teddy*) on the GoTalk by the fourth treatment session. Like Evan, he would often verbalize the target after it was 'spoken' by the GoTalk. In fact, by the fifth session, Bryan verbally requested *teddy* over 50 times without an immediate model from the clinician or the GoTalk. Also interesting to note, both Bryan and Evan were frequently observed verbalizing the target as they were reaching to select it on the GoTalk, which is suggestive of some kind of priming effect. By end of treatment, Bryan was creatively combining up to three symbols on the GoTalk to request favored routines, such as playing on the swing and going home. In fact, much to the chagrin of investigators, Bryan would often select and repeat target words from his GoTalk that had not yet been treated. In some cases the selection of untreated words appeared more like practice than explicit communication since they often were not paired with eye contact or visual reference to specific items in the room. Regardless, the clinician would acknowledge such selections and then attempt to redirect Bryan's interest. For an example, if Bryan selected 'TV' on the GoTalk before treatment had begun on this word, the clinician might have said something like "I don't have that here, let's play with teddy instead."

Although the independent impact of AAC on speech production was not under investigation, some data emerged that speak to its potential influence. Specifically, one can see from Figure 2 that Bryan began spontaneously labeling certain symbols during the probes before the words had been explicitly treated; specifically four words from target set three. Two of these four words were frequently selected by Bryan on his GoTalk and subjected to a form of 'self-practice' during previous treatment phases. On a related note, three of the four control targets that Bryan spontaneously labeled during the post-treatment and maintenance assessments were symbols that had been available on his sister, Kelly's, GoTalk, because they were treatment targets for her (i.e., *hammer*, *candy*, and *happy*). Recall that these two children were siblings and seen at the same time in different rooms. Before or after Bryan's treatment sessions, he would often come into his sister's room and explore her GoTalk, again offering a form of 'self-practice' for these specific words that were not available for the other control words. Similar to Bryan, Evan frequently selected the target 'balloon' on his GoTalk prior to explicit treatment of the word, and this is the one word from the third target set that Evan produced accurately on the box task prior to explicit treatment (see Figure 3).

Such anecdotal evidence from this study is consistent with the position that AAC facilitates communication in general by allowing users to bypass the strenuous linguistic or motor demands of voluntary speech production and concentrate directly on establishing key communicative skills (Millar et al., 2006; Romski & Sevcik, 1996). In specific regard to speech, access to a speech-output device can give children some control over what auditory models they hear and when, thereby increasing the likelihood that they will hear words modeled when they are meaningful to the child (cf. DeThorne et al., 2009). In sum, the present study may add to the emerging evidence that speech-output devices could serve an important role in facilitating speech development, particularly in children with motor-planning challenges.

Varied Intonation Patterns

Although slowed and exaggerated intonational patterns were utilized with all three participants, the effect on eliciting successful imitations was most notable for Kelly. As noted in the participant description, Kelly did not have overt signs of difficulties with motor planning. In fact, she often produced phrases from television programs, familiar songs, or frequent social exchanges with clarity that met or exceeded expectations for phonological development at her age. However explicit attempts to elicit imitation were often unsuccessful with Kelly, particularly if the verbal model was not presented in a novel way. Two forms of evidence that are discussed next support the important role of varied or novel speech patterns when eliciting imitation from Kelly.

Referring to Figure 4, Kelly initially responded well to the clinician's attempts to elicit imitation of targets in motor practice, consistently reaching 100% accuracy in this task despite inconsistencies in her spontaneous use of targets during play. The clinician's models during motor imitation were consistently being presented with a slowed and exaggerated intonation consistent with melodic intonation therapy (Albert, Sparks, & Helm, 1973). However, it became increasingly difficult to engage Kelly in the motor practice task, as documented by her variable performance throughout the second half of her first treatment phase (i.e., sessions 12 through 22). Many changes were made starting on session 17 (e.g., integration of real photos on session 17 and objects on session 19) that may have contributed to her revived performance during motor practice. Interestingly, eminent changes were noted once the clinician used varied intonation patterns when modeling the targets during motor practice starting on session 22. Specifically, the clinician began to alternate between whispered models and models with exaggerated intonation. With this modification and others (see procedures section), Kelly's successful imitation during motor practice climbed back to 100% and remained high throughout the remainder of treatment. In order to experimentally examine the potential role of providing models with varied intonation, the clinician administered the modified card-labeling probe between sessions 33 and 34 that consisted of alternating between whispered models and models produced with varied intonation. With this modification, Kelly's imitation of targets during probes reached 100%--a stark contrast to the 0% imitated during the standard probe administered before and after the modified-probe (refer to Table 4).

Kelly's response to varied and/or exaggerated intonation patterns can be linked to two themes found in prior research. First, research on melodic intonation therapy has documented the facilitatory influence of exaggerated intonation on articulation (see DeThore et al., 2009 for a review). The rationale is that use of melody recruits brain regions in the right hemisphere that are parallel to marked speech production regions of the left hemisphere, specifically perisylvian areas (Jeffries, Fritz, & Braun, 2003). On a similar note, it is possible that exaggerated intonation allows children to shift their focus to the overall message rather than explicit articulatory demands of specific speech sounds (Wade, 1996). A distinct but potentially related finding from prior research is that children with ASD demonstrate reduced attention to speech, relative to other forms of acoustic information, than do typically-developing peers and children with other types of developmental disabilities (e.g., Klin, 1991; Klin, 1992; Paul et al., 2007). Of particular interest, a study by Whitehouse and Bishop (2008) suggested that children with ASD may attend to speech in a similar fashion to same-aged peers when speech is interspersed with contrasting acoustic stimuli—in other words when speech is presented as a 'novel' stimuli. Within this context, Kelly's performance could be interpreted as an increased tendency to imitate speech when it is presented in a novel fashion. Novel within the context of the present study, meaning with exaggerated intonation initially and later as an alternating form of presentation with the use of a whispered voice. The clinical implication of this interpretation would be that providing variations on the acoustic properties of speech input might facilitate both attention and production for some children with profiles similar to Kelly.

Functional Carrier Phrases Within Playful Routines

As evident in part through gains in spontaneous target production across treatment sessions (see Figures 2 through 4), functional carrier phrases were success in eliciting production of target forms from all three children. The clinician and child would establish well-liked games and routines that were linked to functional phrases that incorporated the treatment targets. For example, Kelly enjoyed playing a 'tickle-game' during which the clinician would sequentially inch a toy giraffe toward Kelly while saying, "here comes the…giraffe!" Once the routine became familiar, the clinician could stop before completion of the phrase and Kelly would complete it with the target word *giraffe.* As another example, the clinician would target the word *happy* with Evan by placing happy and sad faces on different animal pictures. The clinician would ask: "is the monkey sad? No… he's ____ (and Evan would answer *Happy*!). Prior evidence has documented the facilitatory effect of functional phrases within the context of predictable routines (e.g., Kim & Lombardino, 1991; see also DeThorne et al., 2009). Of particular relevance to the present study, Yoder and colleagues (1995) found that verbal routines had a particularly strong effect on increasing mean length of utterances (MLU) in children at the single word stage. The shared history of verbal routines is thought to provide a comfortable degree of predictability for the child that in turn may reduce the information-processing load of the communicative exchange (Yoder, Spruytenburg, Edwards, & Davies, 1995). On a related note, carrier phrases provide a meaningful context that is able to capitalize on various aspects of semantic and syntactic priming (DeThorne et al., 2009).

The employment of communicative routines also highlights the important point that intervention is a bi-directional process in which child and clinician are exerting mutual influences on each other. Although the focus is often on the clinician's use of prompts and strategies to shape the child's behavior, the clinician's willingness and ability to shape her interactions according to a child's interests and strengths seems to be an important part of the therapeutic dynamic. In fact, the growth in Kelly's use of target words across treatment sessions may have reflected the clinician's increasing abilities to provide prompts that supported the interaction more than actual changes in Kelly's acquisition of the target forms. This interpretation is supported by the comparison of Kelly's production of targets during intervention and the modified box task to her failure to use any of these forms during the standard assessment procedures in which the routinized interactions were not introduced. Although Kelly's case may represent an extreme in regard to the role of carrier phrases and routine interactions within the intervention process, all three children appeared to benefit from this component of the treatment.

Consideration of Why Effects were Not Apparent for Kelly

Although certain components of the intervention appeared useful for Kelly, the overall treatment did not clearly lead to the desired result of facilitating her communicative use of multisyllabic productions. Specifically, Kelly's production of the targets appeared highly contingent on the clinician's use of verbal prompting (e.g., carrier phrases), a finding that is consistent with prior research documenting challenges with communicative spontaneity in children with autism as well as a strong reliance on prompts or supplementary stimuli (Charlop et al., 1985; Hsu-Min & Carter, 2007). Despite Kelly's strength in imitation, limitations in her use of communicative intent and symbolic understanding may have limited her ability to fully capitalize on the intervention provided. Throughout treatment, Kelly frequently produced fluent strands of melodic jargon that often included recognizable words. However, her verbalizations were rarely paired with gesture or visual reference in a way that specified them as communicative (cf. Calandrella & Wilcox, 2000; Wetherby, Watt, Morgan, & Shumway, 2007). In fact, the clearest communicative acts were most often nonverbal and nonsymbolic. For example, she tried to gain access to a toy up on a shelf by climbing up on the clinician as if she were a ladder or Kelly would continue to extend a song in which the clinician bounced her on her lap by beginning to bounce up and down again once the song had ended. Related to the point of deficits in symbolic communicative intent, Kelly would sometimes push buttons on the GoTalk when presented with it; however, the vast majority of instances were not paired with gesture or visual reference in a way that made the selections meaningful to the clinician. Although the treatment was modified to try and accommodate Kelly's profile by utilizing photos and objects instead of symbols, increasing use of functional carrier phrases in meaningful routines, and increasing the modeling of gestures and symbolic play, neither the treatment or the assessment was fully geared toward facilitating gains in the domains of communicative intent and symbolic understanding. In addition to the modifications employed, prior literature suggests that children with weaknesses in these domains might benefit from a less symbolic AAC system such as PECS to facilitate communicative intent (Bondy & Frost, 1994; Charlop-Christy, Carpenter, Le, LeBlanc, & Kellet, 2002).

It seems important to note that definitions of spontaneous productions differ across investigations, this study defined a production as spontaneous if it was produced in the absence of a model or if it was produced more than five seconds after a model was provided. Consequently, our definition of spontaneous productions allowed for dependence on verbal prompting such as familiar carrier phrases, which would not be considered synonymous with use of the term across all studies (see Carter & Hotchkins, 2002; Halle, 1987; Koegel, O'Deil, & Koegel, 1987; Stone & Caro-Martinez, 1990). Although others might argue that that Kelly's dependence on verbal cueing is problematic; it could also be viewed as a means of scaffolding successful communicative interactions given Kelly's current developmental profile. Regardless, it appears that Kelly would have benefitted most from an intervention that worked more directly on facilitating her skills in communicative intent and symbolic understanding with little need to include explicit motor practice or other methods of facilitating articulation such as visual-tactile cueing.

Limitations

Kelly's case helped highlight limitations in the assessment protocol as well as the treatment approach. Specifically, Kelly's limitations in communicative intent and symbolic understanding may have been more readily noticeable if the initial assessment included a direct measure of these skills, such as the *Communication and Symbolic Behavior Scales* (CSBS; Wetherby & Prizant, 2002). In the future, explicit assessment of these skills would likely lead to more accurate matching between individual children's profiles and the better-suited intervention strategies. On a similar note, more structured and frequent assessment of skills in symbolic understanding and communicative intent may have revealed greater treatment gains, particularly for Kelly and Bryan who had more clear difficulties in communication interactions. Such gains would have been undocumented in the present study given the explicit focus on phonological and semantic skills rather than pragmatics and play skills.

On the topic of assessment, it is difficult to systematically assess children's spontaneous production of target forms in a way that is representative of everyday communicative opportunities. For example, the card-labeling task relied on children's ability to recognize the symbols for various targets. This was fairly straightforward for words like *bubbles* and *apple*; but it became more challenging in cases like *empty*, *open,* or *pony*, the latter easily being confused with 'horse.' Also, the card-labeling task by nature only elicited one form of communicative intent: labeling; this may not have reflected the children's ability to use these targets for other purposes, such as commenting or requesting. For this reason, the box task was designed as an additional probe, intended to mirror more naturalistic interactions with objects during play.

Despite this strength, one disadvantage of the box task was that there was no direct pressure to produce every target form, potentially leading to underestimations of the children's production capabilities. Interestingly, the strengths and weaknesses of both forms of the assessments were apparent from the children in this study. For example, Bryan learned the picture symbols with relative ease and demonstrated this skill consistently in the card-labeling paradigm, which was used both through the probing procedure and the multiple assessment points. In fact, one could argue that he did not produce the control targets during assessment points due to unfamiliarity with the symbols rather than an inability to produce the words. However, the majority of the symbols for both control and treatment targets were highly transparent. Bryan's performance of producing the treatment targets during the box task was less consistent. He failed to spontaneously use targets from both target sets two and three in which he had used spontaneously during play in treatment sessions. Although labeling symbols was a relative strength for Bryan, the same task failed to capture the full extent of Evan's functional word learning, potentially because he did not associate all the cards with their intended targets. For example, Evan used the word *open* frequently during play and in the box task, but did not label the symbol for *open* accordingly during card-labeling task. In another example, he used the word *horse* to label the symbol for target *pony*, which is certainly a reasonable substitution. In short, it is difficult if not impossible to design one measure that accurately captures all of the intricacies of communicative competence, and multiple measures are warranted.

In addition to limitations in the assessment tasks used, concerns regarding external validity are always worth noting. Inherent in single-subject designs, is the likelihood that results will not generalize uniformly to other children with communication disabilities. The goal was to provide enough detail regarding participant profiles, as well as the rationale for individual strategies, to help readers make reasonable predictions regarding the usefulness of this approach for other children. In brief summary, children in the single-word stage of development, whose speech-language delays appear to be due in part to motor-planning challenges, are currently thought to be most likely the best suited candidates for this approach. It is worth noting, however, that even with an appropriate candidate, aspects of this intervention may be difficult to implement in other settings. For example, sessions lasted 45 minutes and were conducted up to three times a week. Also, parents were allowed to view sessions via a parent observation room as often as they would like. Bryan and Kelly's mother was present for close to every session; Evan's parents would typically observe for a part of each session. Therefore, whether or not the treatment or control targets were explicitly practiced at home was not controlled. In addition, many of the sessions benefitted from a ratio of two adults to one child, which offered more support that is often available to practicing teachers and speech-language pathologists. With that said, there is little reason at this point to suggest that key features of this intervention could not be implemented successfully in other settings.

On the point of key features, it is important to reiterate that the present study offers little definitive evidence regarding which aspects of the intervention were most effective. Although this study offered positive results for both Evan and Bryan, it was designed to evaluate the effectiveness of a hybrid approach as a whole, rather than its individual elements. Most notably, the independent contributions of motor practice and developmental strategies remain unclear, but can be gleaned in part through prior literature. In theory, either aspect of the present study's intervention could have been solely responsible for the treatment effect, which is a question left open for future investigation. However, it is also feasible to consider that maximum treatment effects are dependent on combined approaches, especially for children with complex communication needs.

Summary and Conclusions

Despite limitations, this study presents encouraging clinical implications regarding the use of a hybrid approach for children at the single-word stage of development. In particular the approach appeared most promising for children with motor planning breakdowns, with or without a concomitant ASD diagnosis, particularly if basic symbolic understanding and communicative intent have emerged. This present document is intended to help provide specific examples of how such an intervention could be implemented, and to highlight the importance of thinking about the specific cognitive processes that may be underlying speech-language difficulties. Such causal processes do not always map directly onto current medical diagnoses. Future studies might consider focusing on the effectiveness of specific strategies for children with similar underlying cognitive deficits, such as difficulties in motor planning or communicative intent. Particularly promising leads from the present study include integrating the following strategies within meaningful communicative routines: access to a speech-output device, use of functional carrier phrases, and modeling of targets with varied intonation patterns.

CHAPTER V

Figures

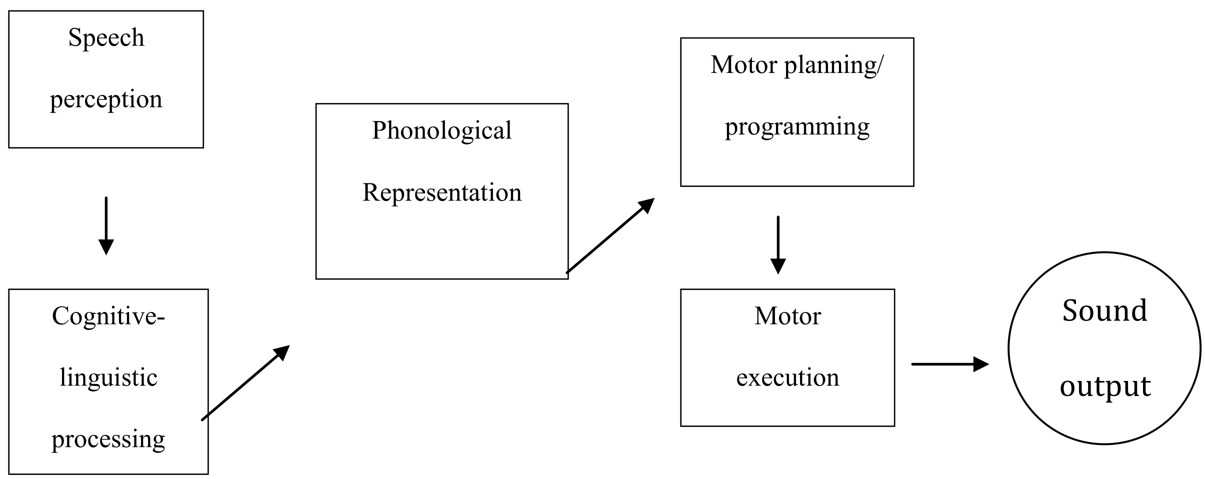

Figure 1. Speech chain.

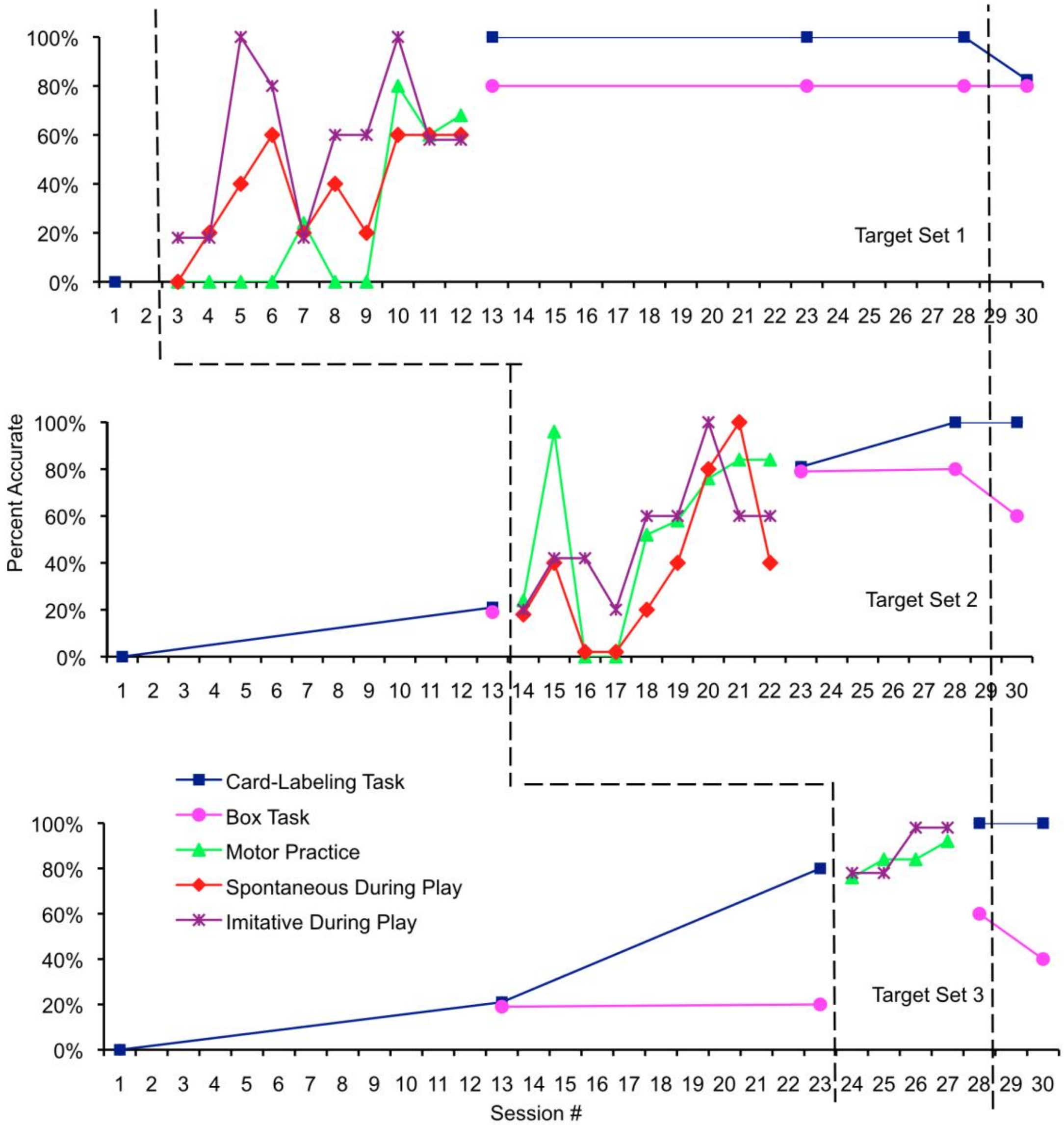

Figure 2. Bryan's treatment data. Criterion for correct responses included verbal marking of all syllables and correct production of at least 50% of the target phonemes. Motor practice was based on a mix of imitative and spontaneous productions depending on the degree of prompting needed. Scored productions for the box task were always non-prompted and spontaneous. Scored productions for the card-labeling task were always spontaneous, except for initial baseline in Bryan's case (which was imitative).

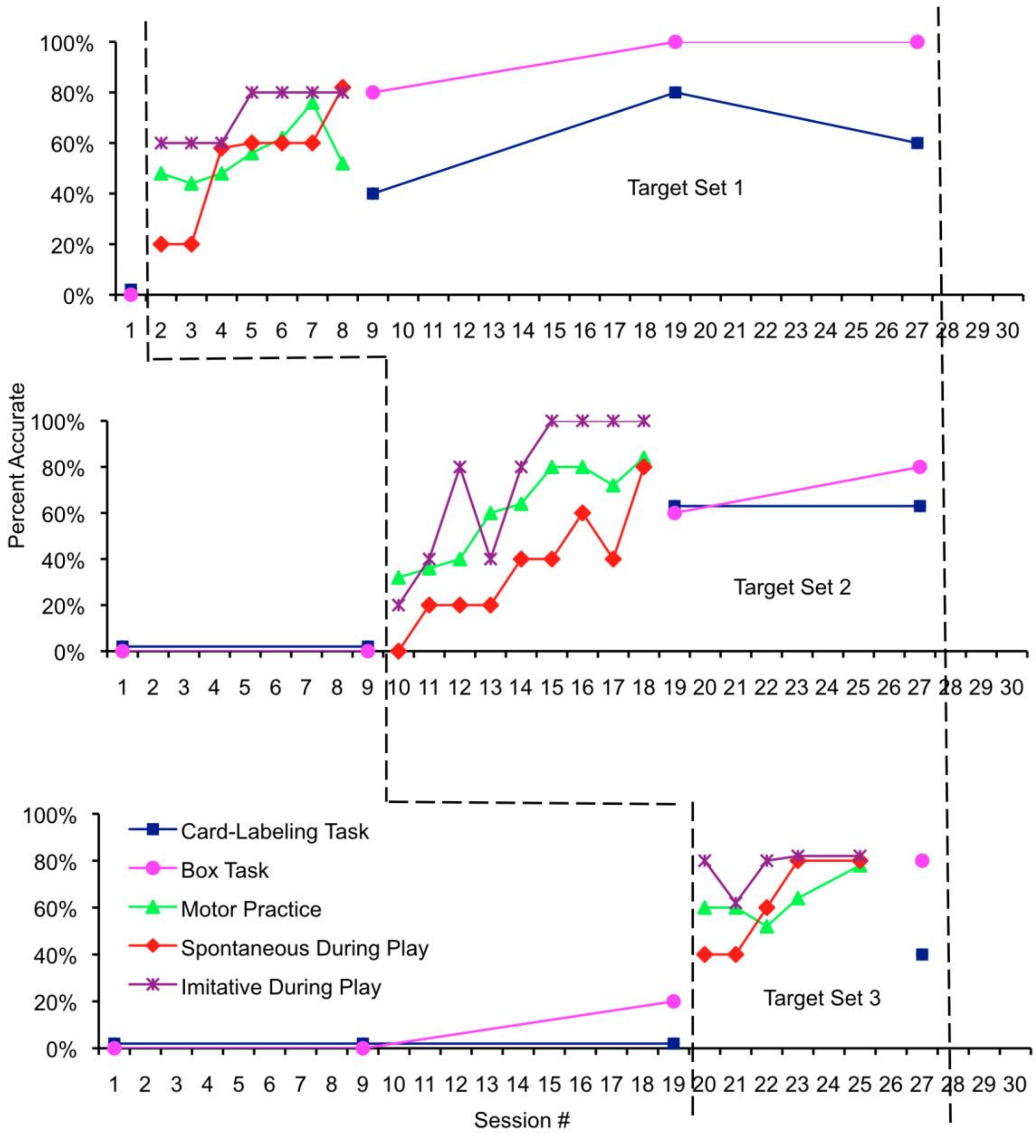

Figure 3. Evan's treatment data. Criterion for correct responses included verbal marking of all syllables and correct production of at least 50% of the target phonemes. Motor practice was based on a mix of imitative and spontaneous productions depending on the degree of prompting needed. Scored productions for the box task and card-labeling task were always spontaneous.

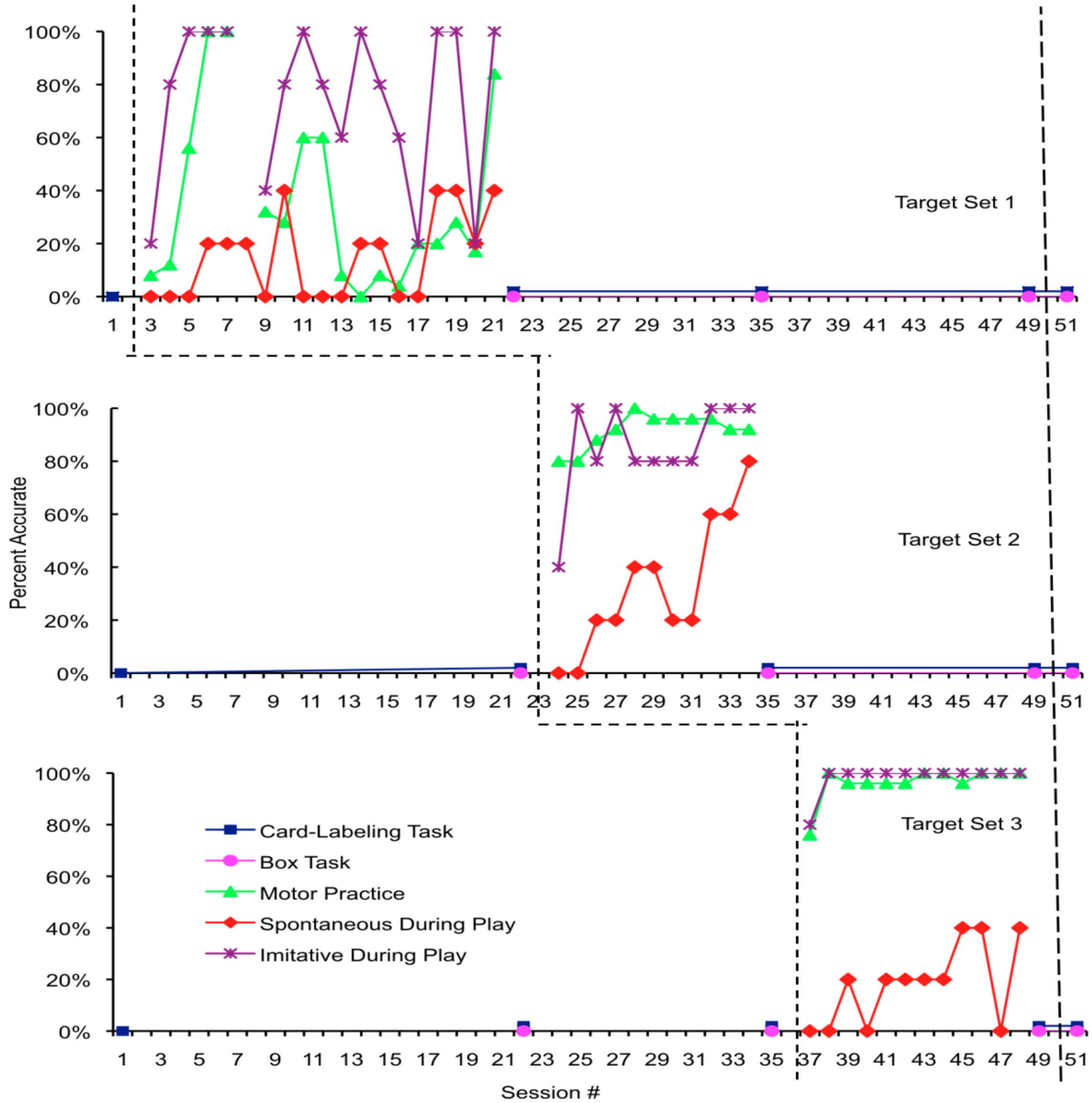

Figure 4. Kelly's treatment data. Criterion for correct responses included verbal marking of all syllables and correct production of at least 50% of the target phonemes. Motor practice was based on a mix of imitative and spontaneous productions depending on the degree of prompting needed. Scored productions for the box task were always non-prompted and spontaneous. Scored productions for the card-labeling task were always spontaneous, except for initial baseline, which in Kelly's case was imitative.

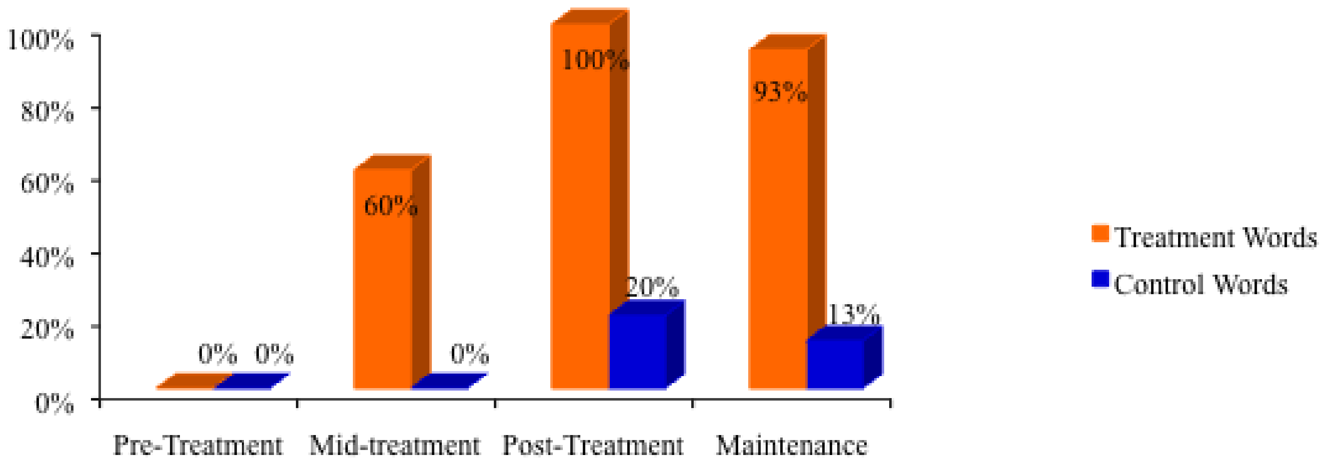

Figure 5. Bryan's pre-, mid-, post-, and maintenance assessment data.

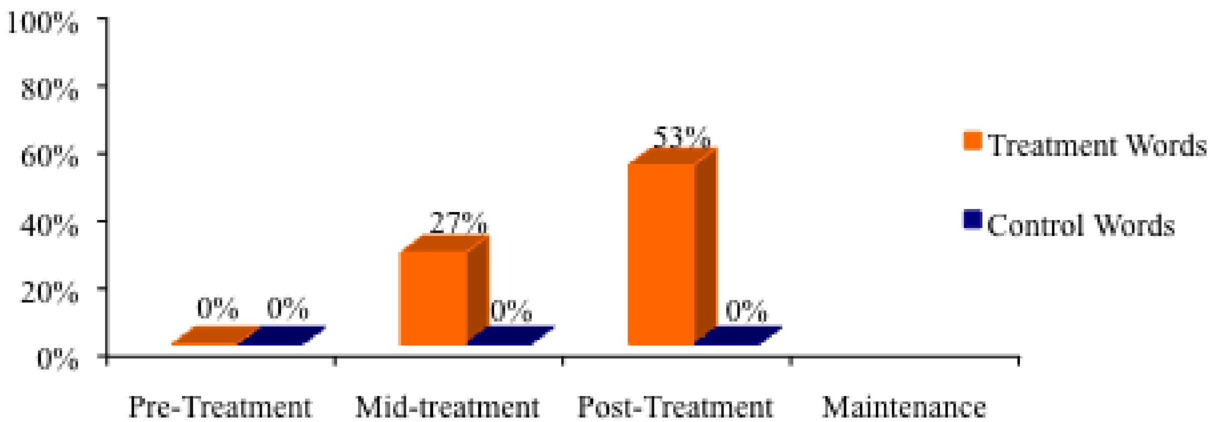

Figure 6. Evan's pre-, mid-, post-, and maintenance assessment data.

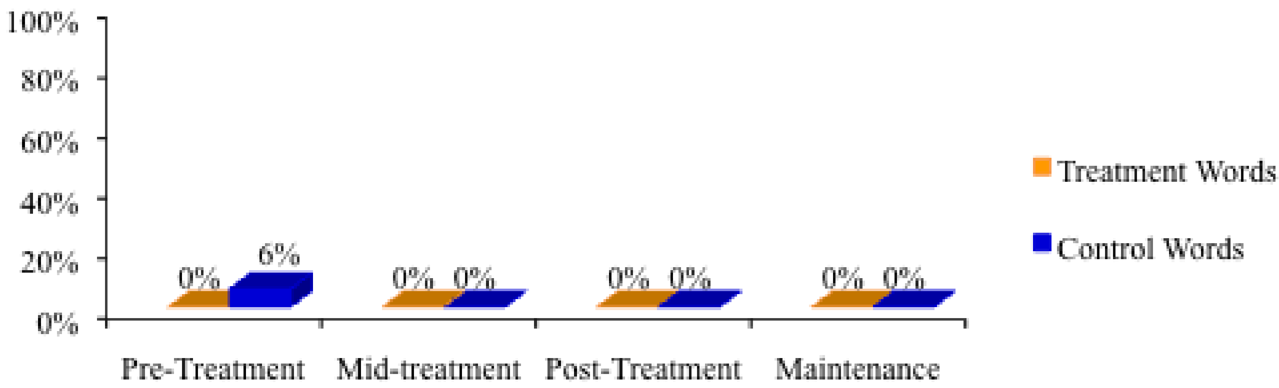

Figure 7. Kelly's pre-, mid-, post-, and maintenance assessment data.

CHAPTER VI

Tables

Table 1

Typical Speech and Language Benchmarks

Lang. Phase and Age	Language domain	Variables	Range in typical development
First Words	Phonology	CV combinations	CV-CVC
12-18 months	Semantics	# of different words used in 20 min	2-15 words
	Pragmatics	# of different communicative functions	2-5 functions
Word Combinations	Phonology	CV combinations	CV-CCVCC
18-30 months		Word structures	1- to 3-syllable words
		% fully intelligible	40%-80%
		Consonant inventory	8-18 consonants
	Semantics	# of different words used in 20 min	10-50 words
	Grammar	MLU	1.1-2.4 (in morphemes)
	Pragmatics	# of different communicative functions	3-6 functions
Sentences	Phonology	% fully intelligible	70%-100%
30-48 months		Consonant inventory	16-24 different consonants; 75% correct
	Semantics	# of different word roots	70-136 in 65 utterances
	Grammar	MLU	2.7-4.0 in morphemes
	Pragmatics	Discourse functions	Narrative

Note. CV= consonant-vowel; CVC= consonant-vowel-consonant; MLU= Mean length of utterance. Adapted from "Defining spoken language benchmarks and selecting measures of expressive language development for young children with autism spectrum disorders" by H. Tager-Flusberg et al., 2009, Journal of Speech, Language, and Hearing Research, *52,* p. 648-649.

Table 2

Individual Participants' Descriptions

Participant	Age	Gender	Race/ Ethnicity	Diagnosis	Consonantal Repertoire	Observations
Bryan	4; 0	Male	Caucasian	ASD & Apraxia	/p,b,g,m,w/	Emergent verbal imitation- most vocalizations were made with lips sealed (/m/ productions), consonant and vowel distortions, limited attention to adult-directed tasks, restricted communicative intentions: nonverbal social engagement (infrequent eye-contact, nonverbal turn taking) Language Sample: Did not spontaneously use multisyllabic productions. Vocalizations were made with lips sealed.
Evan	3;0	Male	Caucasian	Apraxia	/p,b,t,d,k,g,m, n,w,f,s, ʃ, ʧ,ʤ/	Spontaneous 1-word utterances, varied communicative intents, shared attention & turn taking Language Sample: Used three spontaneous and intelligible multisyllabic productions (all two-syllables each).
Kelly	3; 0	Female	Caucasian	ASD	/b, t, d, k, g, w, j, h, s, ʃ,ʤ/	Melodic & unintelligible jargon-like productions, nonverbal turn-taking, emergent letter identification, restricted communicative intentions: nonverbal protesting & social engagements via eye contact Language Sample: Did not spontaneously use intelligible multisyllabic productions.

Note. Phonetic repertoire data were gathered during initial observations and assessments.

Table 3

Inter-Rater Reliability Data

	Bryan	Kelly	Evan
Baseline card-labeling assessment	30/30 (100%)	30/30 (100%)	30/30 (100%)
Mid-treatment card-labeling assessment	29/30 (96.7%)	30/30 (100%)	27/30 (90%)
Post-treatment card-labeling assessment	27/30 (90%)	30/30 (100%)	28/30 (93%)
Maintenance card-labeling assessment	29/30 (96.7%)	30/30 (100%)	--------
Baseline box task	--------	--------	14/15 (93%)
Two-part probe: Card task 1	13/15 (86.7%)	15/15 (100%)	14/15 (93%)
Two-part probe: Box task 1	15/15 (100%)	15/15 (100%)	14/15 (93%)
Two-part probe: Card task 2	13/15 (86.7%)	15/15 (100%)	
Two-part probe: Box task 2	13/15 (86.7%)	15/15 (100%)	
Two-part probe: Card task 3	13/15 (86.7%)	15/15 (100%)	
Two-part probe: Box task 3	13/15 (86.7%)	15/15 (100%)	
Treatment: Spontaneous productions	13/15 (86.7%)*	23/25 (92%)*	12/15 (80%)*
Treatment: Imitative productions	11/15 (73%)*	24/25 (96%)*	14/15 (93%)*
Treatment: Motor practice	73/75 (97.3%*)	123/125 (98%)*	68/75 (90.7)*

Note. Inter-rater agreement percentages were calculated for 10% of each child's treatment sessions; therefore, due to the difference in total number of treatment sessions required for each child, the numerator of treatment data is varied across children but in all cases represents a mean agreement value. *Denotes mean agreement values across 10% of the child's treatment sessions.

Table 4

Results of Kelly's Modified Probe Procedure

	Standard Probe Session # 33	Modified Probe Between session 33 & 34	Standard Probe Session # 46
Card-Labeling Task	0% imitated	(12/15) 80% imitated	0% imitated
Box Task	0% spontaneous without carrier phrases	(4/5) 27% spontaneous with carrier phrases	0% spontaneous without carrier phrases

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Appendix A

Demographics Form

Making Words Meet

Demographic Info

Child ID: ____________________

Please provide the following descriptive information that will be used to describe our study participants:

Child's Race/Ethnicity: ____

Starting with Kindergarten, how many total years of formal education did you complete

(e.g., high school diploma = 13 yrs)? ________________

What is your child's primary language? ____________________

Is your child routinely exposed to any language other than English?

YES/NO If yes, please elaborate.____

____

Please provide any additional information that you want us to know.

____

____

____

____

Thank You!

Appendix B

Bryan's Targets and IPC Ratings

Target List 1 (Untreated)	Category	IPC
Puppy	Animal	0
Bunny	Animal	1
Kitty	Animal	2
Balloon	Toy	3
Candy	Food/Drink	2
Raisin	Food/Drink	3
Penny	Household item	1
Window	Furniture/room	1
Pillow	Household item	2
Hammer	Household item	3
Teacher	People	3
Go Now	Action word	2
Yucky	Adjective	2
Happy	Adjective	2
Sleepy	Adjective	3
	Untreated Total IPC:	30

Target Set	Target List 2 (treated)	Category	IPC
1	Teddy	Animal	0
	Bubbles	Toy	3
	People	People	3
	Open	Action word	2
	Empty	Adjective	2
		Total IPC:	10
2	Pony	Animal	1
	Noodle	Food/Drink	2
	Water	Food/Drink	2
	Dirty	Adjective	1
	Bottle	Household item	3
		Total IPC:	9
3	Lion	Animal	2
	Apple	Food/Drink	3
	Little	Adjective	3
	Paper	Household item	1
	TV	Furniture/room	2
		Total IPC:	11
		Treated Total IPC:	30

Note: IPC refers to the Index of Phonetic Complexity (Jakielski, 2000). The *IPC* is used to compute the complexity of speech sounds in a given word or utterance. Words and phrases were assigned a specific number of 'points' based on the following phonological features: place, manner, vowels, word shape, word length in syllables, place variegation, presence of clusters, and the cluster type (Jakielski, 2000).

Appendix C

Kelly's Targets and IPC Ratings

Target List 1 (Untreated)	Category	IPC
Tiger	Animal	3
Donkey	Animal	4
Chicken	Animal	5
Water	Food/Drink	2
Diaper	Clothing	2
Paper	Household item	1
Tasty	Adjective	2
Yucky	Adjective	2
Go Now	Action word	2
Teddy	Toy	0
Teacher	People	3
Jacket	Clothing	5
Elephant	Animal	6
Ice cream	Food/Drink	6
Stop it	Action word	4
	Untreated Total IPC:	47

Target Set	Target List 2 (treated)	Category	IPC
1	Giraffe	Animal	5
	Open	Action word	2
	Blow It	Action word	4
	Zipper	Clothing	3
	Candy	Food/Drink	2
		Total IPC:	16
2	Pony	Animal	1
	Butterfly	Animal	7
	Scissors	Household item	5
	Dirty	Adjective	1
	Happy	Adjective	2
		Total IPC:	16
3	Turtle	Animal	3
	Hammer	Household item	3
	Turkey	Animal	3
	Kitchen	Furniture/room	5
	Window	Furniture/room	1
		Total IPC:	15
		Treated Total IPC:	47

Note: IPC refers to the Index of Phonetic Complexity (Jakielski, 2000). The *IPC* is used to compute the complexity of speech sounds in a given word or utterance. Words and phrases were assigned a specific number of 'points' based on the following phonological features: place, manner, vowels, word shape, word length in syllables, place variegation, presence of clusters, and the cluster type (Jakielski, 2000).

Appendix D

Evan's Targets and IPC Ratings

Target List 1 (Untreated)	Category	IPC
Bunny	Animal	1
Water	Outside things	2
Bathtub	Furniture/room	4
Pillow	Household item	2
Raisin	Food/Drink	3
Hurry	Action word	2
Tickle	Action word	5
Inside	Preposition/location	3
Empty	Adjective	2
Diaper	Clothing	2
Puppy	Animal	0
Noodles	Food/Drink	4
Button	Clothing	2
Peekaboo	Game/Routine	4
Picture	Household item	5
	Untreated Total IPC:	41

Target Set	Target List 2 (treated)	Category	IPC
1	Open	Action word	2
	Pony	Animal	1
	Kick It	Action word	4
	Oven	Furniture/room	3
	Table	Furniture/room	4
		Total IPC:	14
2	Paper	Household item	1
	Giraffe	Animal	5
	Zipper	Clothing	3
	Happy	Adjective	2
	Radio	Household item	2
		Total IPC:	13
3	Window	Furniture/room	1
	Under	Preposition/location	2
	People	People	3
	Kitchen	Furniture/room	5
	Balloon	Toy	3
		Total IPC:	14
		Treated Total IPC:	41

Note: IPC refers to the Index of Phonetic Complexity (Jakielski, 2000). The *IPC* is used to compute the complexity of speech sounds in a given word or utterance. Words and phrases were assigned a specific number of 'points' based on the following phonological features: place, manner, vowels, word shape, word length in syllables, place variegation, presence of clusters, and the cluster type (Jakielski, 2000).

Appendix E

Principles of Motor Learning

Principles of Motor Learning Relevant to this Study

Motor learning principles	Comparison	Impacts to this study
Structure of practice conditions		
Amount/Intensity	Low vs. **high**	*High*: A large number of practice trails and sessions: three 50-minute sessions per week, five targets practiced five times each session during "drill" practice and then worked on again during play.
Variability	Constant vs. **variable**	*Variable*: The targets are not only worked on during the "drilled" motor practice, they are also naturally targeted during meaningful, structured play situations.
Target Complexity	Simple vs. **complex**	*Complex:* Difficult sound sequences. Multisyllablic words/word combinations are difficult for the participants.

Note. Comparison options that are expected to enhance generalization according the motor-learning literature are in bold. Adapted from Maas et al., 2008, p. 282.

Appendix F

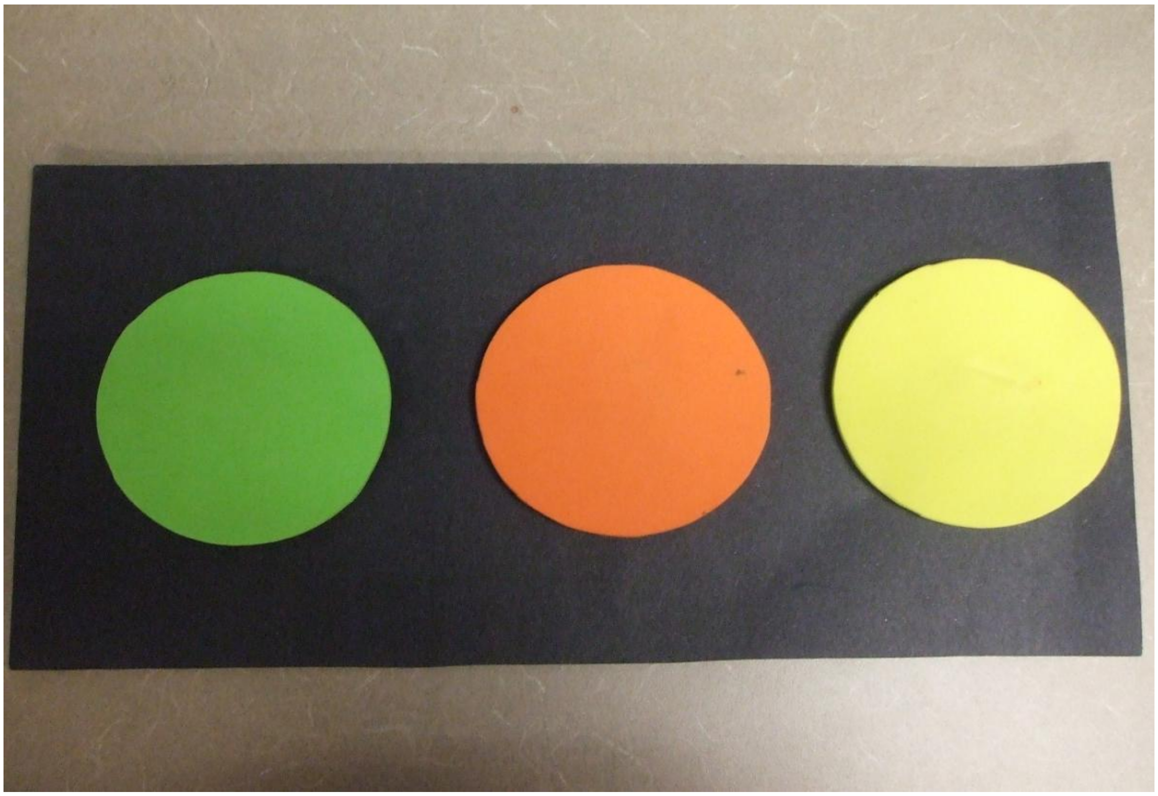
Visual-Tactile Cues

All cues were provided either on the child or to the clinician's self while simultaneously vocalizing the phoneme. Specific cues were based in part on the PROMPT system (Bose et al., 2001; Chumpelik, 1984; Houghton, 2003).

Phonemes	Visual-tactile cues
/t/ & /d/	Using index finger, briefly tap on child's top lip
/b/ & /p/	Using index finger, tap on child's top and bottom lip
/o/	(Draw an O) Circling your own and/or the child's lip with index finger
/n/	Touch the side of the child's nose with thumb
/m/	With thumb, touch the side of the child's nose, while simultaneously using index finger to touch the child's lips
/w/	Use index finger and thumb to pinch the child's corners of the mouth in (promoting lip rounding)
/v/	Use thumb to apply pressure on the bottom lip- folding lip over bottom teeth
/k/ &/g/	Gently tap the region of the hyoid bone
/z/	Pull finger along arm or other surface
/ʧ/	Touch child's lips with index finger tip and extend away from chin in an exaggerated fashion

Appendix G

Pacing Board Example

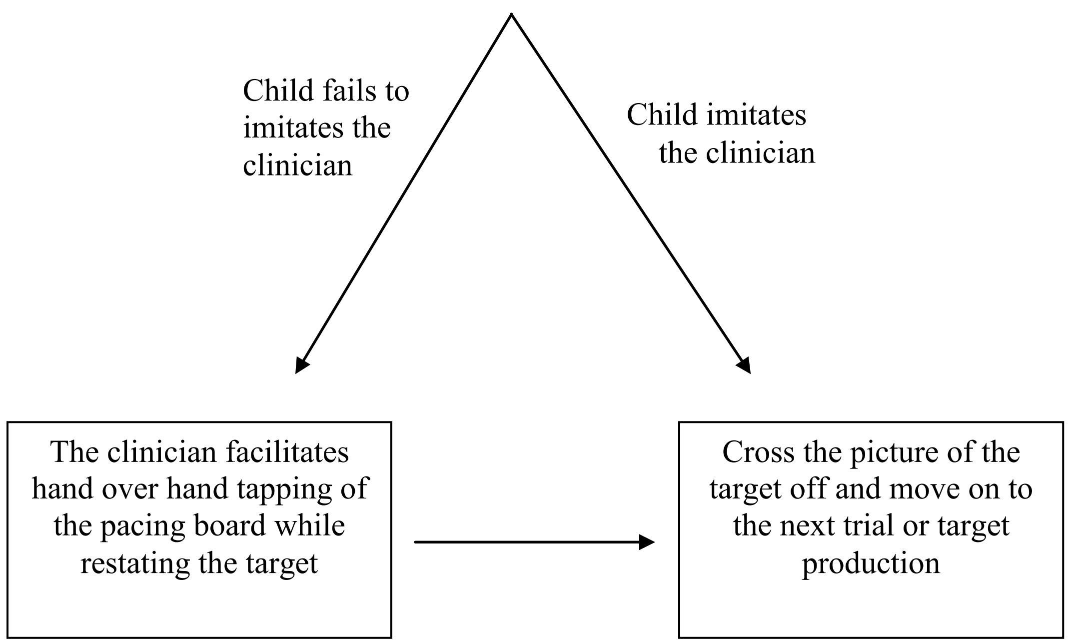


Appendix H

Motor Practice Procedures

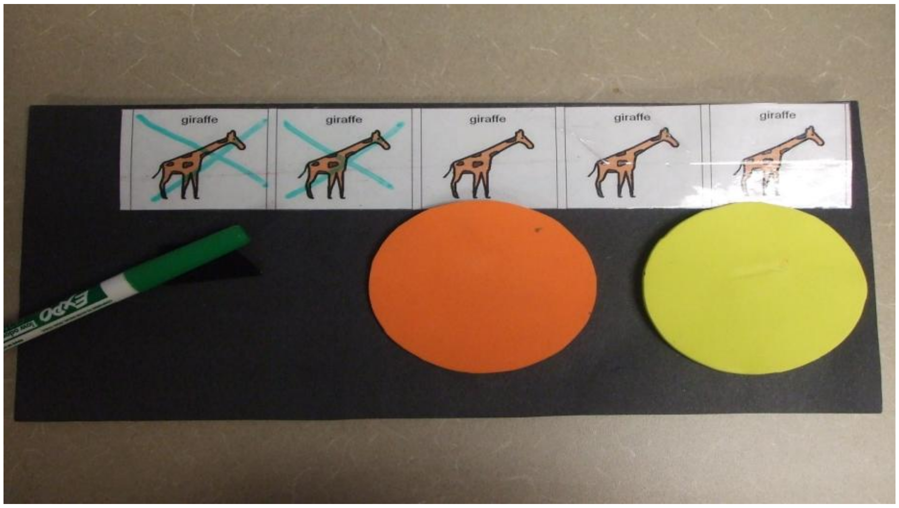
Pacing Board

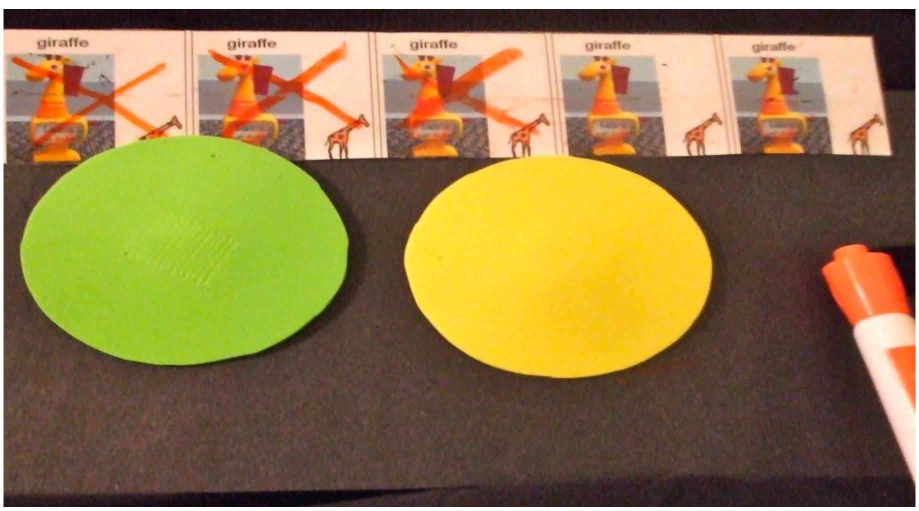
- The clinician models each target by saying the target and simultaneously tapping the pacing board for each syllable
- The clinician then states, “you say it”



Appendix I

Kelly's Visual Strip with Symbolic and Real Pictures





Appendix J

Session Data Collection Form

Target	Child's Motor Practice Production: Imitated/ Spontaneous	# of Clinician Models	# of Tactile Cues Provided by the Clinician	# of Times the Go Talk was Used	# of Elicitations by the Clinician	Child's Imitations after a Model	Child's Spontaneous Uses
____							
____							
____							
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Appendix K

Pre, Mid, and Post Treatment Assessment Procedures

- While holding the puppet, the clinician states, "We're going to help teach Mr. Pony some words today"
- The clinician shows the child a picture of the target and asks the child , "You say Giraffe"

Child fails to attempt the target word

Child repeats or attempts the target word

Clinician presents the child with the Go Talk 20+ and says, "Show me giraffe"

The clinician repeats the steps with the next target word

Child fails to select the correct target word

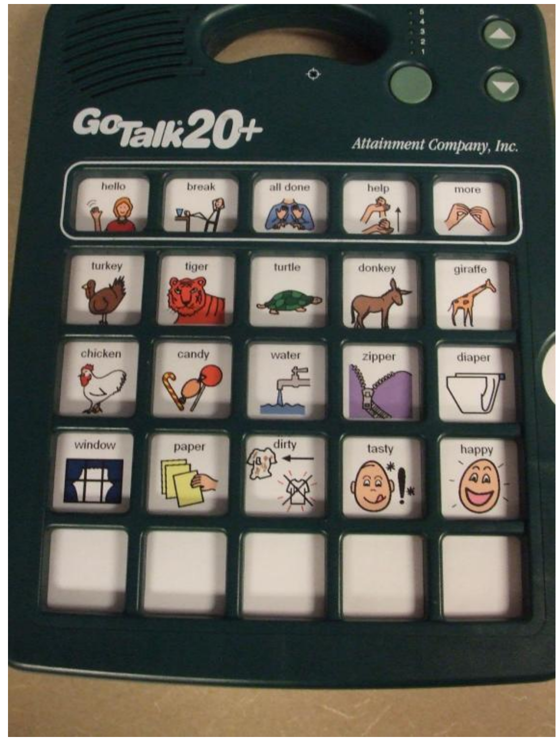
Child selects the correct target word on the Go Talk 20+

The clinician selects the correct target on the Go Talk 20+ using hand-over-hand facilitation

The clinician repeats the initial steps with the next target word

Appendix L

Picture of Probe Overlays

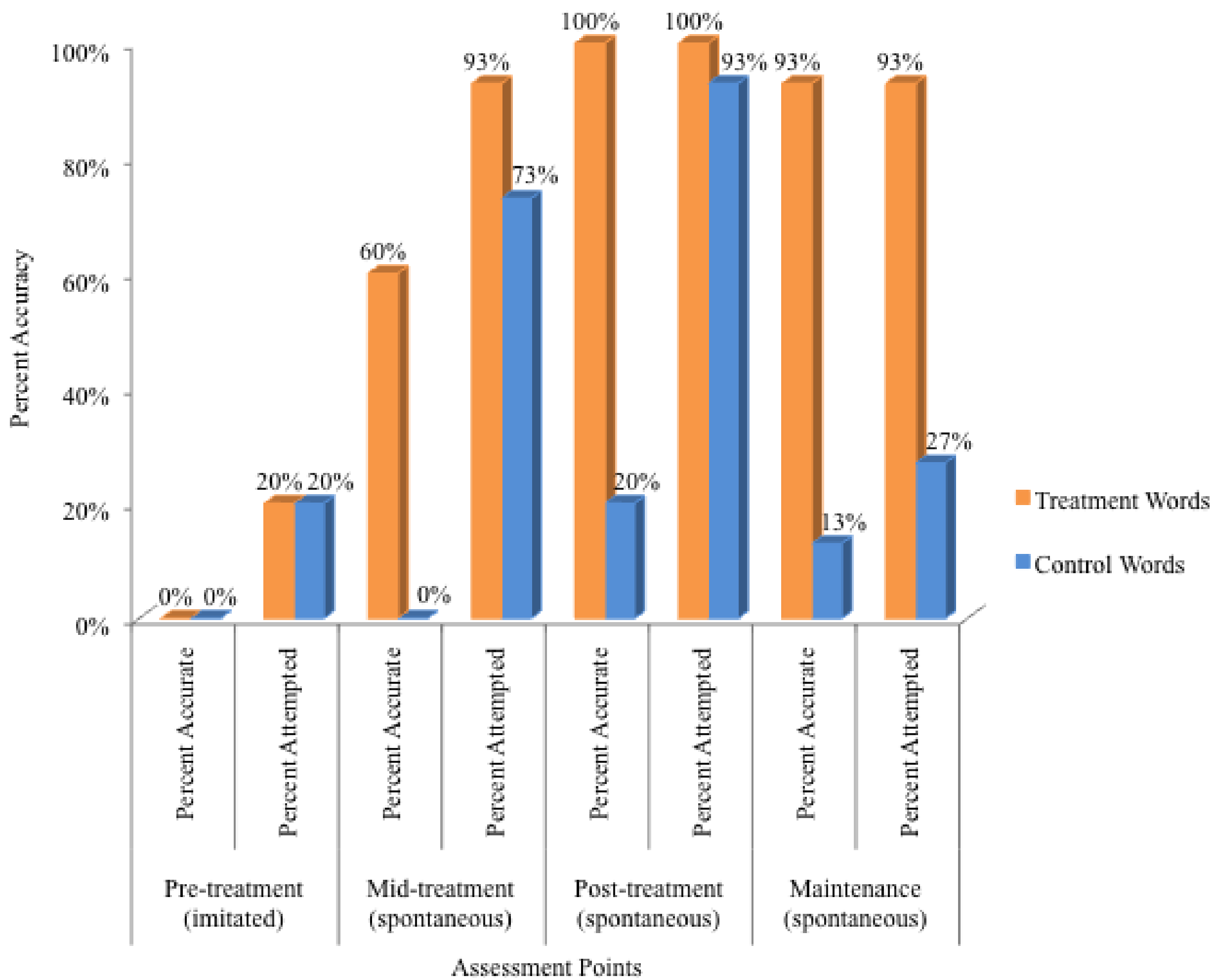


Example of Kelly's Probe Overlays

See Appendix C to reference which targets are treatment targets and which are used with the assessment procedure.

Appendix M

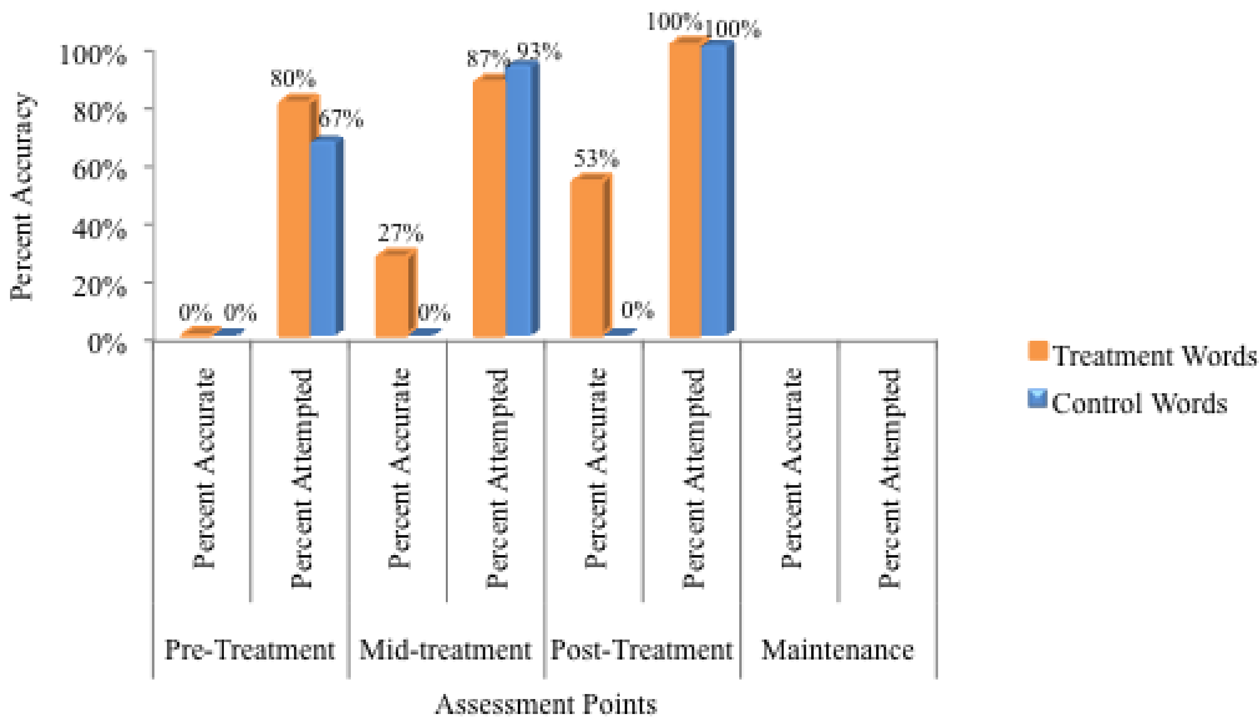
Bryan's Correct Versus Attempted Targets



Note. Bryan's percentage of targets produced correctly compared to the overall percentage of attempted targets during the assessments.

Appendix N

Evan's Correct Versus Attempted Targets



Note. Evan's percentage of targets produced correctly compared to the overall percentage of attempted targets during the assessments.