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UNIVERSITY OF CALIFORNIA

Los Angeles

Communication Growth in Minimally Verbal Children with Autism

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of

Philosophy in Special Education

by

Charlotte Alcestis Mucchetti

2013

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ABSTRACT OF THE DISSERTATION

Communication Growth in Minimally Verbal Children with Autism

by

Charlotte Alcestis Mucchetti

Doctor of Philosophy in Special Education

University of California, Los Angeles, 2013

Professor Connie Kasari, Chair

Very little is known about language and communication development in minimally verbal children with autism, especially those who remain minimally verbal past the age of five. This population is rarely reported on in research and although there is evidence that some children do learn to speak after the age of five, we lack information on the course and characteristics of their language development. Studies that do include this population generally focus on discrete incremental language skills without addressing broader communication and pragmatic skills. Due to the fact that communication and social deficits are both inherent to a diagnosis of autism, an examination of not only what discrete language skills are acquired but how those skills are used in communicative interchanges is relevant. Research on communication development in typically developing children includes attention to early pragmatic and interchange level language use. Information and methods from this body of

literature can be used to guide our exploration of similar abilities in minimally verbal children with autism as they become more competent communicators over time. This study examined the interchange level communication development of 42 children with autism over the course of a six-month play and engagement based communication intervention. Communication interchanges between interventionists and children with autism were observed and characterized at seven time points over six months. Interchanges were coded for frequency, length and communicative function, as well as who (adult or child) initiated each interchange. Communication repair was examined in depth, documenting attempts, success rates and strategies employed by participants. Children were observed to engage in communication interchanges for a variety of communicative functions and these interchanges increased over the course of intervention in terms of frequency, length and the proportion initiated by the child. Children's level of joint engagement at the beginning of the study was positively related to their use of long interchanges over time. 55% of the participants were observed to repair at least once during the study. Most of these repairs were successful and children used a variety of strategies.

The dissertation of Charlotte Alcestis Mucchetti is approved.

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Acknowledgements

This dissertation includes data that were collected as part of the Characterizing the Cognition of Non-Verbal Individuals with Autism (CCNIA) intervention study, conducted across three sites. Connie Kasari PhD, Anne Kaiser PhD and Rebecca Landa PhD were the primary investigators on that study. CCNIA was funded by a grant from Autism Speaks.

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Literature Review

Autism spectrum disorders (ASD) are a group of developmental disorders that currently affect an estimated 1 in 88 children (Centers for Disease Control Prevention, 2012). These disorders are characterized by impairments in communication and social skills, as well as the presence of restricted, repetitive and stereotyped patterns of behavior (National Institutes of Mental Health, 2004). One of the most striking characteristics of autism spectrum disorders is their extreme heterogeneity in appearance, with language being no exception. Some individuals with autism have age appropriate semantic and syntactic skill while other individuals have extremely limited receptive and expressive language. Individuals who are not able to use expressive language to communicate are referred to as “non-verbal” or “minimally verbal”. Definitions of these terms vary throughout the literature such that they may include individuals who use no spoken language at all, or individuals who use some words but are unable to express basic wants and needs reliably. Current estimates are that approximately 30% of individuals with autism remain minimally verbal into adulthood (Anderson et al., 2007; Hus, Pickles, Cook, Risi & Lord, 2007). Children who remain minimally verbal are at greater risk for limited long-term outcomes and lower quality of life (Howlin, Mawhood, & Rutter, 2000). As such, this high-risk subgroup of the autism population requires unique consideration in the literature. Despite the need, minimally verbal children with autism are under-represented in both descriptive and intervention research.

Communication Development in ASD

Language and communication deficits are observed in individuals across the spectrum. Language acquisition is typically delayed, with the average age of first words at 38 months, rather than 12 months (Eigsti, de Marchena, Schuh & Kelley, 2011). Individuals with ASD

generally show greater developmental scatter in the acquisition of grammatical forms, as well as unusual language features – echolalia (non-meaningful repetition of language) and neologisms (idiosyncratic, unconventional ways of referring to things) (Eigsti et al., 2011).

A review by Eigsti and colleagues (2011) summarizes research on language development in individuals with ASD across the spectrum. In addition to universal pragmatic deficits, prosodic abnormalities were documented in all relevant studies. Findings regarding syntax, morphology and phonology were mixed, with some studies showing deficits and some showing intact skills (eg. Eigsti, Bennetto & Dadliani, 2007; Lake, Cardy & Humphreys, 2010). Semantic skill seems to be the most intact language domain, as most studies have shown individuals with ASD performing similar to mental age matched peers on tests of vocabulary and categorization (Eigsti et al., 2011). Although impairments in prelinguistic attentional skills are thought to negatively impact word learning in many individuals with ASD, there is evidence that some children with ASD are able to use joint attention to learn novel words (i.e. following the gaze of an adult as they label an object) as typically developing children do (Luyster & Lord, 2009). The vast majority of research on language in individuals with ASD uses participants who have fluent language. It is unclear to what extent these results can inform our understanding of communication in minimally verbal children.

Language outcomes. Language outcomes among individuals with autism are of great interest to both the clinical and research communities, and estimates of how many individuals eventually develop language vary. Previous estimates reported up to half of individuals with autism failed to develop spoken language (Pickett, Pullara, O’Grady & Gordon, 2009), but with recent increases in early identification and intervention, that number is dropping. Longitudinal research (Anderson et al, 2007) with 98 children with autism found that 29% of the sample

remained minimally verbal at age nine and another 24% were only able to communicate with single words. A large scale descriptive study looking at 1,000 individuals with ASD from ages 4-52 found that 13% of the sample used no words at all while an additional 20% of the sample used only single words to communicate (Hus et al., 2007). In children who are not completely non-verbal but have very limited linguistic repertoires (minimally verbal), their language is typically characterized by a very small repertoire of single words or fixed phrases that are used at very low rates and are only in limited contexts (e.g. to request a preferred item within a familiar context) (Kasari, Brady, Lord & Tager-Flusberg, submitted).

While most children who develop spoken language do so before age five, there is growing evidence that later language is possible. A review by Pickett and colleagues (2009) found 167 documented cases of children with autism who developed speech after the age of five (though most by age seven). Most of the 167 children were eventually able to communicate with words and sounds, while a subset developed phrases and sentences. Research exploring the communication abilities of minimally verbal children with autism, especially those over the age of five, is very sparse. While there was much variability in the outcomes reported, consistent findings were that rapid progress was made once children began speaking, and generally more hours of intervention led to better speech outcomes (Pickett et al., 2009). In a recent case study, Gordon (2010, as cited in Tager-Flusberg & Kasari, submitted) reported on a boy who had only one spoken word at age 12 and was able to develop a large single word vocabulary. Now age 22, he is continuing to add words to his vocabulary. This case study highlights the fact that the development of spoken language may still be possible at later ages.

A more recent records review documented initially minimally verbal children going on to develop more language at higher rates than previously thought (Wodka, Mathy & Kalb, 2013).

The authors examined assessment records of 535 children with autism who did not have flexible phrase speech by age 4. They found that 70% of these children did go on to attain phrase or fluent speech by age 8, based on assessment results. This estimate is higher than those previously reported, and raises the possibility that many initially minimally verbal children can go on to develop more speech. This highlights the importance of conducting more research to characterize this population and inform intervention efforts. More research is needed to further document late speech acquisition as well as explore interventions to maximize communication in this population. In order to inform intervention efforts for minimally verbal children with autism, it is necessary to further document communication development in this elementary-age population.

Language predictors. An emphasis on early identification of children with autism has led to work documenting the communication skills of children with autism as early as two years of age and following those children longitudinally to observe their developmental trajectories. Thurm, Lord, Li-Ching & Newschaffer (2007) followed 118 children (with autism, PDD-NOS and other disabilities) from 2 years to 5 years. They found that non-verbal cognitive ability at age 2 and communication score at age 3 were the best predictors of language at age 5 in the autism group. Additionally, joint attention and joint engagement have been established as pivotal for language development. Joint attention is the active coordination of shared attention between a partner and an object, and includes skills such as pointing and showing (Adamson, Bakeman & Deckner, 2004). Joint engagement refers to the state in which the child and communication partner are actively sharing attention with each other and an object. Communication during periods of joint engagement (symbol infused joint engagement) appears to facilitate language development as the amount of time a toddler spends in symbol infused joint

engagement predicts their later language ability (Adamson et al., 2004) over and above their early language skills. Initiating and responding to joint attention are powerful concurrent and future predictors of language ability in children with autism (Luyster & Lord, 2009) and typically developing children (Watt, Wetherby & Schumway, 2006).

This close relationship between the ability to jointly engage with a partner and the development of language skills highlights the interaction between social and communication skills during development. Although these skills are often treated as separate constructs, they are in fact interdependent.

Interaction Level Communication Skills

Since both communication and social deficits are fundamental to the disorder of autism, it is crucial that we explore how these skills intersect. An analysis of these interaction level communication abilities (communication used in the context of interaction) allows us to explore how well children with autism are using the small set of communication skills they possess in order to get their needs met. It is possible (indeed likely) that children with similar linguistic skill may still vary in their communicative competence. Two children with the same vocabulary size and mean utterance length may nonetheless differ in their ability to use those skills in order to make themselves understood. Although there is a substantial body of research examining pragmatic skills in verbal children with autism, there is a paucity of information on equivalent skills in minimally verbal children. This may be due in part to the inherent difficulties in collecting data on communication skills in minimally verbal children. However, there are a variety of studies examining early communication skills in typically developing children, some of which may guide efforts to collect similar information on older, minimally verbal children.

Research on language development in typically developing children has included a focus on pragmatic and interpersonal interchange level early communication skills. These skills may be seen as an intersection between discrete communication skills and social ability, as they include not only what skills an individual possesses, but how those skills are used in interpersonal interaction. Observational studies as well as experimental designs have revealed information regarding the course of early social language development.

A longitudinal study of communication in parent-child dyads used a complex coding system to characterize several aspects of children's early communication at 14, 20 and 32 months. The authors documented changes in the children's communication over time using a novel coding system, the Inventory of Communicative Acts-Abridged (Snow, Pan, Imbens-Bailey & Herman, 1996). They found that the rate of communication attempts increased greatly over the time points, as did the proportion of successful communication. The authors examined both speech act and interchange level communication. Interchanges were defined as "one or more rounds of talk all of which serve a unitary interactive function implicitly agreed upon by the interlocutors" (Snow et al, 1996, p. 58). They found that communication interchanges were just beginning to emerge in children at 14 months. Children at 20 months consistently used a small range of interchange types, and were most likely to use negotiating the immediate activity, directing the hearer's attention and discussing a joint focus. Discussing clarification of verbal communication was an emerging category at this age. Children at 32 months engaged in a wider variety of interchange types and the types most common at 20 months were less common at this age. Discussing clarification of verbal communication increased from 50-60% of the children at 20 months to 81-86% of the children at 32 months. Interchange types based on non-concrete information (such as discussing recent events or thoughts and feelings) which were rarely

observed at 20 months were observed in 54-70% of the children at 32 months. The category of “discussing clarification of verbal communication” maps onto the general linguistic concept of communication repair. There is a large body of research on communication repair in verbal individuals (often called conversation repair), which is less applicable to minimally verbal children with autism. However, a handful of experimental studies have documented communication repair in very young typically developing children.

Communication repair. Communication repair is the ability to persist in communication with another person and to repeat, modify or recast the communication signal if the initial communication fails (Meadan & Halle, 2004). It is considered an indicator of communicative intent, since engaging in repair indicates that the previous communicative act was intentional. Repair emerges over time and has a consistent developmental course in typically developing children, where instances of repair increase over time and strategies employed change over time (Meadan, Halle, Watkins & Chadsey, 2006). Engaging in communication repair can be considered social in addition to linguistic, since the individual must recognize communication breakdowns and modify their next communicative turn based on the response of their communicative partner.

Research on communication repair in young, typically developing children has demonstrated that children seek to be understood even when their needs are met – that is, they engage in repair when the adult indicates verbal misunderstanding, even if they receive the target of their request. Grosse, Behne, Carpenter & Tomasello (2010) replicated and extended earlier work by Shwe and Markman (1997) demonstrating that children as young as 18 months attempt communication repairs when the adult communication partner demonstrates misunderstanding, even when the child’s request is completed. Children were shown high interest objects and

asked which one they wanted. In three conditions the experimenter verbally demonstrated that they understood the request (“you want the ducky” when the child requested ducky) but varied in delivering the object (gave object immediately, told child to wait, did not give object and interpreted child’s request as comment). In the other two conditions, the experimenter verbally showed misunderstanding (“you want the ball” when the child asked for the ducky) and either gave the correct object “by accident” or gave the wrong object. Children were significantly more likely to repair communication when the adult appeared to misunderstand but gave the correct object than when the adult understood and gave the correct object, indicating that children were motivated to repair the communication even when their goal of gaining the object was met. Children were also significantly more likely to repair the name of the object in the condition where the adult gave the wrong object and repair the function of the communication (request rather than comment) in the condition where the adult interpreted the request as a comment, indicating that children were able to discern the source of the adult’s misunderstanding.

Observations of communication repair have also been used to document progress in adult patients with aphasia (Boles, 1998) and hearing loss (Tye-Murray, 1991), in cases where the change is too idiosyncratic to be detected by standardized tests. In these studies, participants demonstrated increased rates of repair initiation (Boles, 1998) and increased range of repair strategies (Tye-Murray, 1991) over the course of communication intervention.

A handful of studies have investigated the use of communication repair by individuals with autism, as a marker of communicative intent. Minimally verbal children with autism have demonstrated the ability to recognize communication breakdowns and attempt to repair them in both naturally arising interactions with their mothers (Keen, 2005) and in experimental situations (Meadan et al., 2006). Keen (2005) investigated communication repair in a sample of six

preschool age minimally verbal children with autism and found that participants were more likely to repair by repeating their signal or substituting a different type of signal, and less likely to augment their original signal by adding to it. Meadan et al. (2006) analyzed videotapes of two children with autism in a scripted session designed to elicit repair attempts. They concluded that the repair topographies of participants were similar to those of typically developing pre-verbal children as reported in the literature, although a comparison group was not included in the study. The participants repaired 70% of their unsuccessful communication attempts, and the repair strategies varied between the children and across activities and breakdown types. These studies represent a focus on communicative intent. That is, not merely how individuals come to produce words, utterances and sentences, but how they use those discrete skills to make their intentions known to a communicative partner. Research on typical language development has transitioned from a singular focus on discrete language skills to including broader examination of children's communicative intentions (Snow et al., 1996). Employing a similarly expanded focus in examining communication development in minimally verbal children with autism will serve to increase our understanding of how these children acquire and use communication.

Communicative Intent Framework

An early paper by Prizant & Wetherby (1987) proposed using the concept of “communicative intent” as a framework for understanding communication in children with

autism. They suggested that communicative intent research in typically developing children can provide a standard of reference to create and test models of communication development in autism. Communicative intent was defined as “the ability to use expressive signals in a preplanned manner in order to affect the behavior or attitudes of others” (p. 472). They proposed that communicative intent was an appropriate way to frame the study of communication in autism, due to the fact that communication depends on the interaction between raw communication skill and social relatedness and cognition.

Mundy and Markus (1997) expanded on this framework by suggesting that the specific pattern of social communication deficits in autism is the result of a dysfunction in frontal neurological processes. They propose that it is necessary to use a dynamic systems perspective in order to understand the complexities of the social communication difficulties in autism. A dynamic systems perspective emphasizes the dynamic, interactive nature of different cognitive systems, in which behavior and skill development is heavily influenced by these interactions and not due to any single cognitive component.

These frameworks provide researchers with a guide for structuring and conceptualizing the study of communication skills in minimally verbal children with autism. Using the concept of “communicative intent” allows researchers to focus on whatever methods a child uses in order to accomplish a communication goal, rather than focusing on an established set of communication skills that children with autism may not display. Taking a dynamic systems perspective on top of the communicative intent framework promotes a more holistic view of communication skills in the context of the child’s other cognitive skills and deficits.

Measuring communication in context. Accurately assessing and characterizing communication in children with autism who are minimally verbal presents a variety of

challenges. These children have often developed idiosyncratic communication strategies that may not be detected by structured assessments or unfamiliar assessors. Additionally they may display communication skills inconsistently, making it difficult to truly assess their capabilities during the short time period provided during a standardized assessment (Paul & Wilson, 2009). Minimally verbal children with ASD may perform at the floor on most standardized assessments and are often reported in research as simply “untestable”.

The use of observation data may lead to a more accurate description of communication abilities in minimally verbal children with autism, especially when observations are repeated in consistent circumstances over time. The current study characterized children’s communication based on detailed coding of videotaped intervention sessions, repeated frequently over time. This facilitates understanding of participants’ true communication abilities in practice.

Language Interventions for Minimally Verbal Children

Research on language and communication intervention for minimally verbal children over the age of 5 is extremely sparse. Of this limited body of research, most has focused on increasing discrete speech and language skills and is reported in single subject studies. These include naturalistic interventions, which are focused on teaching children in the natural environment (e.g. Charlop-Christy & Carpenter, 2000, Mancil, Conroy & Haydon, 2009), and Functional Communication Training, which uses behavioral methods to shape idiosyncratic communication into more functional forms (e.g. Keen, Sigafos & Woodyatt, 2001, Jennet, Harris & Delmolino, 2008, Hart & Banda, 2010). These interventions target functional communication using primarily behavioral methods, with a focus on using language to request, often in response to adult prompts (Tager-Flusberg & Kasari, submitted). Interventions for minimally verbal children with autism rarely address language initiations or language used for

broader communicative functions. Although these studies report some success in teaching minimally verbal children to increase rates of requesting in specific situations, it is unclear to what extent these new skills generalize to other communication environments.

A smaller subset of this body of research has investigated using interventions that target joint attention and joint engagement in order to increase language abilities. Intervention targeting joint attention skills has been effective in increasing play, joint attention initiations and expressive language in pre-school age children with autism (Kasari, Freeman & Paparella, 2006). In this randomized controlled trial of 58 children with autism, joint attention intervention and symbolic play interventions were compared to a control group. Children with the least amount of language made the most progress in the joint attention intervention, indicating that this approach might be especially suited to minimally verbal children (Kasari, Paparella, Freeman & Jahromi, 2008).

The use of augmentative and alternative communication (AAC) with minimally verbal children with autism has received increased attention in recent years. AAC includes forms of communication other than speech that may be used to express thoughts, needs and wants (American Speech-Language-Hearing Association, 2013), such as sign language, picture symbols, or speech generating devices (SGDs). SGDs produce voice output in response to the user pushing a button or graphic symbol displayed on the device. The use of these devices with minimally verbal children with autism is increasing in popularity, although there is still minimal research about their effectiveness (Brady, 2010). The use of AAC devices with minimally verbal children with autism has generally been investigated with single subject designs, and most studies have found modest gains in child language, primarily in the domain of requesting (Schlosser & Wendt, 2008; Schlosser et al., 2007). Romski and colleagues (2010) investigated

the use of speech generating AAC devices within a parent-mediated naturalistic language intervention for toddlers with developmental delays who had fewer than 10 expressive words. Participants were randomized to receive intervention with spoken language alone, intervention in which the parent modeled language using the AAC device, or intervention in which the child was prompted to communicate using the AAC device. Many participants did not use spoken language at any time during the study, but the authors found that a higher proportion of children in the AAC intervention groups used spoken language at the end of the study than in the speech only intervention group. These findings raise the possibility that the use of AAC devices in intervention for minimally verbal children may lead to increased spoken language outcomes, in addition to augmented language.

Gaps in the Literature

There is very limited research on communication abilities of minimally verbal children with ASD. Although there is evidence that some children do develop language after age 5, very little is known about the characteristics of their communication or the course of their communication development. Studies documenting language in this population primarily focus on discrete speech skills, so even less is known about interchange level communication abilities. Research on communication repair in minimally verbal children with autism is very sparse, and studies include few participants.

Contributions of the Current Study

The current study characterized interchange-level communication in 42 minimally verbal children with autism, as well as documented change in these skills over the course of a six-month intervention. This study is a secondary data analysis of a multi-site intervention study with

minimally verbal children with autism 5-9 years old. Videotaped intervention sessions were coded to capture characteristics of communication interchanges between participants and interventionist. These communication abilities were described at multiple time points, and changes in them modeled over time. This study includes a larger number of participants than previous research, which allows for more rigorous methodology and analysis of results. This information increases our understanding of the communicative capacity of minimally verbal children with autism, potentially informing intervention efforts.

Aim 1: Document communication repair in minimally verbal children with autism over the course of a six-month communication intervention.

1.1 Document the frequency, success rate and strategies used for communication repair at each time point.

1.2 Examine growth in frequency and success rate of communication repair.

Aim 2: Examine communication interchanges in minimally verbal children with autism over the course of a six-month communication intervention.

2.1 Document frequency of interchanges, average length, child initiations and communicative functions at each time point

2.2 Examine growth in frequency and child initiations of communication interchanges

Aim 3: Examine predictors of communication interchange use in minimally verbal children with autism over the course of a six-month communication intervention.

3.1 Examine the impact of chronological age, receptive language, autism severity and joint engagement as predictors of communication interchange growth.

3.2 Examine frequency of early communication interchanges as a predictor of expressive language change.

Methods

Participants

The participants included 42 minimally verbal children with autism who participated in the Characterizing Cognition in Non-Verbal Individuals with Autism (CCNIA) study at University of California Los Angeles (n = 22) and Vanderbilt University (n = 20). The participants were recruited from various community programs and school districts serving children with autism. Inclusion criteria for the study included a primary diagnosis of autism, chronological age between 5 and 8 years at entry, fewer than 20 spontaneous words on a standardized language sample and developmental level of at least 24 months as measured by standardized assessments. Exclusionary criteria included a diagnosis of other syndromes or disorders (e.g. seizure disorder, cerebral palsy). Table 1 summarizes participant characteristics. There were no significant differences between sites in these characteristics at entry.

Table 1

<i>Participant Characteristics</i>						
Site		Age ^a	Non-Verbal Mental Age (Leiter-R) ^a	Receptive Language (PPVT-4) ^a	Number of Different Words	Mean Length of Utterance
UCLA	<i>M (SD)</i>	6:6 (1:1)	4:3 (1:1)	2:10 (0:9)	17.63 (13.43)	1.53 (0.68)
VU	<i>M (SD)</i>	6:3 (1:1)	3:9 (1:4)	2:8 (0:9)	14.24 (13.82)	1.17 (0.28)

^aYears:Months

Participants who completed at least four out of the seven time points of the original study were included in the current study. There were 42 participants who completed the first three months of the study. Of these, 36 participants completed all six months of the study. There were

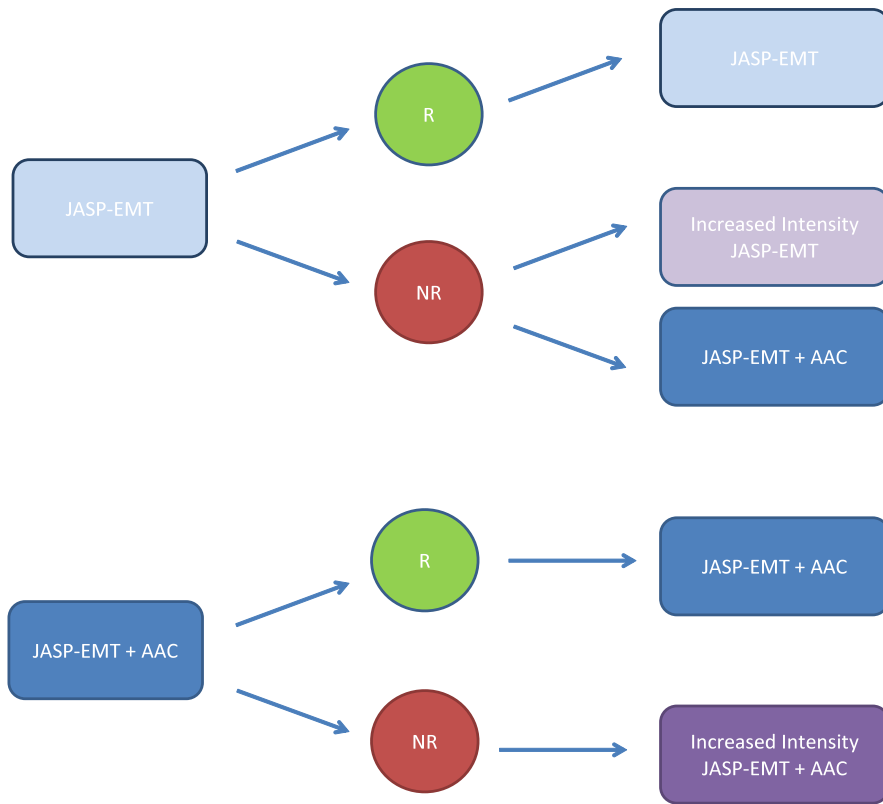
two additional participants with missing data at months 1, and one additional missing at months 2, 4 and 5 due to missing or incomplete video recordings.

Design

Participants were randomly assigned to one of two joint engagement based intervention conditions: one in which spoken language was the primary mode of communication (JASPER-EMT) and one in which a speech output device was incorporated as another mode of communication (JASPER-EMT + AAC). The components of the intervention were otherwise identical between these two conditions. See the intervention section below for more information on the intervention. During stage one of the study (months 1-3), participants received a 45-60 minute intervention session twice per week. At the end of stage one (week 12), participants were assessed to determine whether they were responding to the intervention. Responder criteria were pre-determined, and both standardized assessments as well as variables coded from videotaped session data were used to determine responder status. Participants who were determined to be responders continued in the same intervention condition. Participants who were not responders based on the criteria were re-randomized to either increased intensity of their original intervention condition, or switched to the JASPER-EMT + AAC condition for stage 2 (months 4-6) of the study. In total, participants received 6 months of intervention. For 36 participants, this included 48 intervention sessions. Six participants were re-randomized to increased intensity for stage 2, and so received 60 intervention sessions in total.

Figure 1

Study Design



Intervention

The basis for both interventions conditions is Joint Attention, Symbolic Play and Emotion Regulation (JASPER; Kasari et al, 2006; 2008) and Enhanced Milieu Therapy (EMT; Kaiser & Roberts, 2011). The goal of JASPER is for the child and interventionist to be in a state of supported or coordinated joint engagement throughout as much of the session as possible. In these states, the child is aware of the interventionist’s activity and coordinates their attention between a toy and the interventionist (Adamson et al., 2004). This is facilitated through specific strategies including a) following the child’s interest, b) using contingent language (e.g. talking about the child’s activity, expanding on what the child says), c) sitting in front of the child and d)

making environment adjustments to engage the child (e.g. moving interesting toys into view). Components of EMT are incorporated to elicit communication. Child specific language targets are selected and modeled throughout sessions by the interventionist. The interventionist repeats and expands child communicative attempts and specific language is elicited through the use of a hierarchical cue sequence (milieu episode).

In the JASPER-EMT condition, spoken language is the primary mode of communication, although the interventionist also responds to other forms of child communication such as vocalization and gesture. JASPER-EMT + AAC uses the same base intervention format and strategies, but includes a speech generating alternative and assistive communication (AAC) device as an alternative communication mode. The AAC device is programmed with a set of visual-graphic symbols appropriate to the play. The AAC device is used by the interventionist along with spoken language throughout the session and child use of the AAC device is responded to as spoken language.

Measures

Autism Diagnostic Observation Schedule. Module 1 of the ADOS (Lord, Rutter, DiLavore & Risi, 1999) was administered at entry to confirm a diagnosis of autism. The ADOS Module 1 is a 30-45 minute semi-structured behavioral observation and is a standard instrument for making a research diagnosis of autism. Module 1 was given because it is the module intended for children who are minimally verbal. The ADOS yields a numerical score in the domains of communication and social reciprocity as well as an overall score.

Language Sample. The language sample is a 21-minute free child-examiner play interaction using five toy sets (Kaiser & Roberts, 2013). The examiner uses minimal language to introduce each toy set (e.g. “We have some play-doh. What should we make?”) and otherwise

only repeats language that the child spontaneously uses. Language samples were transcribed and analyzed according to Systematic Analysis of Language Transcripts (SALT) guidelines (see “Intervention Session Transcription and Coding” below) to yield main language variables. Language samples were conducted at entry, midpoint (month 3) and exit (month 6).

Leiter International Performance Scales – Revised. The Leiter-R (Roid & Miller, 1997) is a completely nonverbal assessment of general cognitive ability that is often used to assess who are cognitively delayed and/or have limited expressive language. A developmental age-equivalent as well as standardized IQ score can be calculated. The Leiter-R was conducted at entry and used as the measure of non-verbal mental age.

Peabody Picture Vocabulary Test – Fourth Edition. The PPVT-4 is a 10 to 15 minute long test of receptive vocabulary. The child chooses the 1 picture from 4 that best illustrates the word pronounced by the examiner. A developmental age-equivalent and standardized score can be calculated. The PPVT-4 was administered at entry and used as a measure of receptive vocabulary.

Intervention Session Transcription and Coding

Expressive Language. Ten-minute clips of intervention sessions at all seven time points were transcribed using SALT conventions (Miller & Iglesias, 2008; see appendix A for additional transcription conventions). Transcripts were then analyzed in SALT to yield a variety of variables, including number of different word roots (NDWR), number of social communicative utterances (SCU). These variables are primary outcome measures in the CCNIA study and are part of the criteria for determining responder status. Transcription is done by multiple graduate students and research assistants. Reliability of transcription is monitored among transcribers to maintain an intra-class correlation coefficient of at least 0.80.

Routines and Engagement. The same intervention session clips are also coded for play routines. Various characteristics of play routine quality are coded on a 4-point Likert scale and the duration of each play routine is recorded. The total time spent engaged in routines within the first intervention session is used as a measure of joint engagement. Play routines coding is completed by multiple graduate students and research assistants. Reliability is monitored among the coders to maintain an intra-class correlation coefficient of at least 0.80.

Communication Interchanges. The transcripts were then coded for the primary variables of interest for the proposed study, using a coding scheme that was developed for this purpose. Sessions were coded by graduate students. Reliability was measured on 20% of the session transcripts and intra-class correlation coefficients ranged from 0.75 - 0.96 across variables. See Table 3 for ICC coefficients by variable. See appendix B additional coding information and definitions.

Each transcript was coded to capture four components of communication interchanges: rate of interchanges, interchange length, interchange initiator and interchange type. Rate of interchanges was calculated as the total number of interchanges occurring in each 10 minute session. Interchange length was calculated as the mean number of turns per episode in each session. Interchanges were then coded for who initiated the interchange – child or adult. Adult non-verbal cues for communication (such as withholding an object or holding up two objects to elicit a choice) were counted as adult initiations. Finally, interchanges were coded for communicative function, using a sub-set of the categories provided in the INCA-A coding system (Ninio, Snow, Pan & Rollins, 1994): 1) establish mutual attention, 2) discuss a joint focus of attention, 3) negotiate possession of an object, 4) discuss thoughts and feelings, 5) discuss the

fantasy world, and 6) discuss clarification of verbal communication. Table 2 summarizes interchange variables.

Table 2

Interchange Variables

Variable	Definition/Types		ICC Coefficient
Frequency	Total interchanges in session		0.96
Initiator	Child or adult		0.76
Length	Number of turns (average across session)		0.75
Function (adapted from INCA-A)	Discuss	Discuss joint focus of attention	0.88
		Discuss thoughts and feelings	
		Discuss fantasy world	
	Negotiate	Negotiate possession of an object	0.91
	Negotiate immediate activity		
	Establish Mutual Attention		0.76
	Clarification of verbal communication (repair)		0.78
	Unknown interchange type		0.82
	Other interchange type		

Communication repair. Interchanges that were coded as serving the function “clarification of verbal communication” were further coded for three components of

communication repair: frequency, strategies and success. The frequency of communication repair attempted by the child was counted and repair episodes were then coded for strategies employed by the child (repetition, substitution, augmentation or negation), and whether the repair was ultimately successful (the adult understood the intended message) or abandoned (the child discontinued the communication attempt without being understood). Reliability was measured on 20% of repair episodes and calculated using kappa coefficients. Repair variables and reliability coefficients are summarized in Table 3.

Table 3

Repair Variables

Variable	Definition/Types	Reliability Coefficient
Frequency	Total repair episodes	<i>ICC</i> = 0.76
Outcome	Successful Abandoned	<i>K</i> = 1.0
Strategies	Repetition (repeat same signal) Substitution (different signal) Augmentation (combined signals) Negation (says “no”, protest)	<i>K</i> = 1.0

Results

Aim 1: Document communication repair in minimally verbal children with autism over the course of a six-month communication intervention.

Of the 42 participants, 23 participants (55%) were observed to repair at least once over the seven time points. Twelve of those participants (29%) repaired multiple times. Table 4 summarizes the repairs observed at each time point.

Table 4

Communication Repair: Frequency and Success Rates Across Time

Month	Number of participants who repaired	Total repairs	Success rate
0	3	3	67%
1	8	9	100%
2	6	9	100%
3	4	6	67%
4	4	7	71%
5	8	9	56%
6	3	6	83%

Each episode of repair was coded for the specific repair strategies used. Because repair episodes occurred at low frequency, repairs from all time points and participants were grouped together for descriptive purposes. Of all the repair episodes observed, 37% contained a repetition of the original communication attempt, 18% contained a substitution of a different communication form, 27% contained an augmentation of the original communication attempt with something additional (such as adding another word or gesture), and 4% contained a simple negation. In

14% of repair episodes, the child combined two or more different strategies within the same episode.

Due to the low frequency of repair episodes, no additional analyses were possible.

Aim 2: Document communication interchanges of minimally verbal children with autism over the course of a six-month communication intervention.

2.1 Describe the frequency, length, child initiations and communicative functions of communication interchanges at each time point.

Descriptive statistics were used to document the frequency, average length, child initiations and communicative functions of interchanges at each time point. Tables 5 and 6 summarize the characteristics of communication interchanges at each time point. The frequency of interchanges (total number per session) increased from an average of 15 at entry to 22.29 at exit in the JASP-EMT group, and increased from an average of 17.05 to 25.89 in the JASP-EMT + AAC group. Both groups showed the highest frequency of interchanges at Month 6. The percent of interchanges that were initiated by the child increased from 57% at entry to 69% at exit in the JASP-EMT group, while the JASP-EMT + AAC group increased from 61% to 71%. Both groups showed the highest percentage of child initiations at the Month 5 time point (72% in the JASP-EMT group, 75% in the JASP-EMT + AAC group). Average length of interchanges (measured as number of turns per interchange) also increased in both groups; from 2.62 (JASP-EMT) and 2.65 (JASP-EMT + AAC) at entry to 3.35 (JASP-EMT) and 3.36 (JASP-EMT + AAC) at Month 6. The JASP-EMT + AAC group showed the longest average interchange length at Month 3 (3.64), while the JASP-EMT group showed the longest average length at Month 6.

Table 5

Frequency, Child Initiations and Average Length of Communication Interchanges Across Time

Month	JASPER-EMT			JASPER-EMT + AAC		
	Frequency	Child Initiations	Average Length	Frequency	Child Initiations	Average Length
0	15.00 (9.92)	57% (24%)	2.62 (.73)	17.05 (8.27)	61% (21%)	2.66 (.81)
1	15.55 (7.27)	61% (16%)	2.60 (.52)	18.65 (5.91)	70% (18%)	2.83 (.64)
2	18.76 (9.80)	66% (23%)	2.78 (.88)	23.60 (8.15)	68% (20%)	2.94 (.59)
3	19.00 (9.26)	64% (26%)	2.89 (1.12)	23.57 (7.08)	62% (15%)	3.64 (1.52)
4	18.82 (8.57)	69% (20%)	2.59 (.44)	24.83 (9.10)	74% (15%)	2.96 (.89)
5	21.06 (8.66)	73% (16%)	2.64 (.30)	24.67 (11.18)	75% (15%)	3.27 (.78)
6	22.29 (9.75)	69% (15%)	3.35 (.84)	25.89 (7.39)	71% (12%)	3.36 (.48)

Note. Results are *M (SD)*

Results for communicative functions at each time point are presented in Table 6. The communicative functions were collapsed into two primary composite variables for analysis. Discuss Joint Focus of Attention, Discuss Thoughts and Feelings, and Discuss Fantasy World were collapsed into a single Discussion variable, due to the fact that Discuss Thoughts and Feelings and Discuss Fantasy World occurred at extremely low rates. Negotiate Immediate Activity and Negotiate Possession of an Object were collapsed into a single Negotiate code, due to the fact that these codes appeared to capture similar constructs within the context of this intervention and the level of reliability was improved when these codes were combined. Because many of the communication interchanges occurred while children were engaged in play routines with established turn taking, it was difficult to determine if the function of an interchange was to negotiate possession of an object (e.g. request a block) or to negotiate the activity (e.g. request to take a turn). Because these functions had similar topography, they were collapsed into a single code. Rates of Establish Mutual Attention and Unknown Interchange

Type are also reported in Table 6. Establish Mutual Attention occurred at relatively low rates, likely due to the fact that one of the primary components of the JASP-EMT intervention is for the therapist to follow the child's attentional focus throughout the session. This greatly reduces the need for the child to use communication to direct the adult's attention. Unknown Interchange Type was coded when the function of the interchange was ambiguous.

Table 6

Frequencies of Communicative Functions Across Time

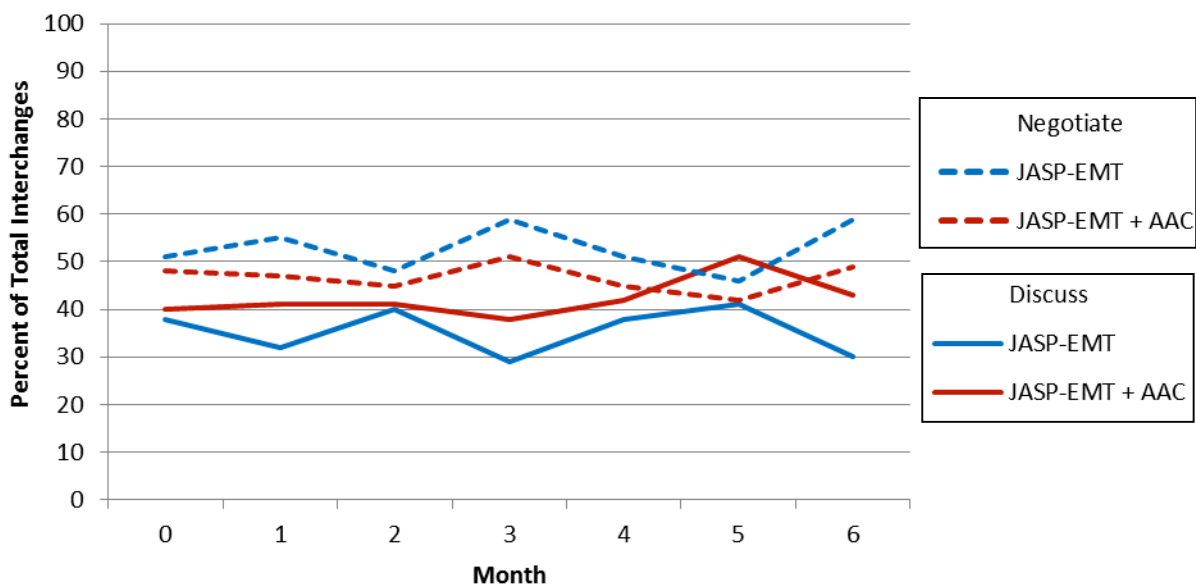
Month	JASPER-EMT					JASPER-EMT + AAC						
	Discuss	Negotiate	Establish Mutual Attention	Unknown Function	Discuss	Negotiate	Establish Mutual Attention	Unknown Functions	Discuss	Negotiate	Establish Mutual Attention	Unknown Functions
0	4.71 (5.44)	7.67 (5.41)	.29 (.717)	2.29 (2.53)	5.48 (4.02)	8.10 (6.95)	.48 (.75)	2.76 (2.28)	5.48 (4.02)	8.10 (6.95)	.48 (.75)	2.76 (2.28)
1	4.05 (3.49)	8.70 (5.05)	1.10 (1.45)	1.60 (2.06)	6.10 (6.22)	8.75 (3.52)	1.25 (1.33)	2.90 (2.86)	6.10 (6.22)	8.75 (3.52)	1.25 (1.33)	2.90 (2.86)
2	6.10 (6.30)	9.05 (4.17)	1.62 (2.06)	1.90 (2.64)	7.45 (5.67)	10.60 (6.28)	1.60 (1.93)	3.85 (4.00)	7.45 (5.67)	10.60 (6.28)	1.60 (1.93)	3.85 (4.00)
3	4.52 (5.02)	11.14 (5.52)	.81 (1.17)	2.52 (2.70)	7.57 (4.58)	12.10 (4.55)	1.43 (1.96)	2.33 (2.35)	7.57 (4.58)	12.10 (4.55)	1.43 (1.96)	2.33 (2.35)
4	6.00 (6.15)	9.59 (5.39)	.82 (1.02)	2.35 (3.16)	8.17 (6.23)	11.11 (6.53)	2.17 (2.04)	3.39 (3.70)	8.17 (6.23)	11.11 (6.53)	2.17 (2.04)	3.39 (3.70)
5	6.71 (4.57)	9.67 (4.86)	1.29 (1.49)	2.53 (3.30)	10.72 (9.43)	10.44 (5.22)	1.56 (1.65)	1.89 (1.49)	10.72 (9.43)	10.44 (5.22)	1.56 (1.65)	1.89 (1.49)
6	5.59 (4.82)	13.24 (7.30)	1.12 (1.76)	2.35 (2.73)	9.74 (5.92)	12.68 (6.04)	.79 (1.03)	2.74 (2.31)	9.74 (5.92)	12.68 (6.04)	.79 (1.03)	2.74 (2.31)

Note. Results are *M (SD)*

Across time points, the proportion of total interchanges that served a “discuss” function ranged from 29% to 41% in the JASP-EMT group and 38% to 51% in the JASP-EMT + AAC group. The proportion of total interchanges that served a “negotiate” function ranged from 46% to 59% in the JASP-EMT group and 42% to 51% in the JASP-EMT + AAC group. These proportions fluctuated over time, but did not appear to trend up or down consistently across time in either treatment group.

Figure 2

Percent of Total Interchanges Serving “Negotiate” and “Discuss” Functions



Growth in child initiations. The proportion of interchanges initiated by the child (out of total interchanges in the session) was modeled using a multi-level mixed model. Due to the fact that data was normally distributed at each time point, the data was not transformed. The data appeared to show a linear relationship over time and so was modeled with a linear equation. The distribution appeared more similar to a continuous variable than the expected distribution for a

proportion variable, so it was modeled with a standard linear model, rather than a Poisson transformed model. There were no main effects of site or treatment groups and no interactions, so the final model included only time.

$$\text{Child Initiations}_{ij} = \alpha_0 + \alpha_1 \text{time}_{ij} + \beta_i + \epsilon_{ij}$$

Table 7

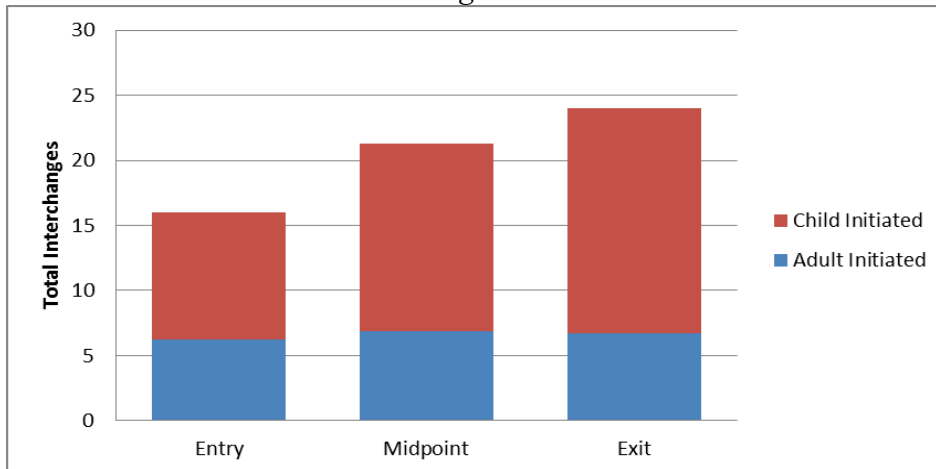
Mixed Model – Child Initiations

Effect	Estimate (SE)	DF	<i>t, F</i>	<i>p</i>
Intercept	.61 (.02)	41	<i>t</i> = 26.31	<.0001
Time	.02 (.005)	1, 228	<i>F</i> = 16.39	<.0001

Within this model, the intercept was free to vary while the slope was fixed. The effect of time was significant ($F(1, 228) = 16.39, p < .0001$), indicating that the proportion of interchanges initiated by the child increased over time. There was no difference between treatment groups or sites in the growth rates over time. On average, children showed an increase of 2% per month in the proportion of interchanges that they initiated.

Figure 3

Child and Adult Initiated Interchanges



Growth in frequency of interchanges. At each time point, there were a large number of interchanges consisting of only two or three turns (one adult turn and one or two child turns) and a smaller number of interchanges consisting of four or more turns. In order to facilitate examination of how participants changed specifically in their ability to engage in longer interchanges, the total number of interchanges was split into two variables for subsequent analyses – short and long interchanges. “Short interchanges” is the total number of interchanges per session that were two or three turns in length. “Long interchanges” is the total number of interchanges per session that were four or more turns in length.

Table 8

Frequency of Short and Long Interchanges

Month	JASPER-EMT		JASPER-EMT + AAC	
	Short Interchanges	Long Interchanges	Short Interchanges	Long Interchanges
0	11.95 (8.14)	3.05 (3.23)	13.71 (3.04)	3.33 (3.04)
1	12.25 (5.60)	3.30 (3.11)	13.6 (1.13)	5.05 (3.94)
2	14.05 (7.87)	4.71 (3.69)	16.6 (3.94)	7.00 (4.08)
3	14.76 (7.75)	4.24 (3.43)	14.90 (.94)	8.67 (5.56)
4	15.06 (7.55)	3.76 (2.44)	17.67 (4.08)	7.17 (5.38)
5	15.94 (6.11)	5.12 (3.55)	15 (.81)	9.67 (6.93)
6	16.06 (6.69)	6.24 (4.62)	17.26 (5.56)	8.63 (3.74)

Note. Results are *M (SD)*

Growth in frequency of communication interchanges was modeled using multi-level mixed models. Data were first examined to ensure that they met the assumptions of mixed models. Data was normally distributed at most time points, and so was not transformed. Data appeared to show a linear relationship over time and so was modeled with a linear equation.

Short interchanges. In the model for frequency of short interchanges, there was no main effect of treatment group and no interaction with treatment group, so it was not included. The model for short interchanges was:

$$\text{Short Interchanges}_{ij} = \alpha_0 + \alpha_1 \text{time}_{ij} + \alpha_2 \text{site}_i + \alpha_3 (\text{time} \times \text{site})_{ij} + \beta_i + \epsilon_{ij}$$

Table 9

Linear Mixed Model Results of the Frequency of Short Interchanges Across Time

Effect	Estimate (SE)	DF	<i>t, F</i>	<i>p</i>
Intercept	15.96 (1.23)	40	<i>t</i> = 12.98	<.0001
Time (Ref: VU)	.12 (.22)	227	<i>t</i> = .57	.57
Site (Ref: VU)	-5.41 (1.70)	(1, 227)	<i>F</i> = 10.20	.0016
Time x Site (Ref: VU)	.92 (.30)	1, 227	<i>F</i> = 9.21	.0027

Within this model, the intercept was free to vary while the slope was fixed. Vanderbilt University (VU) was set as the reference group. The effect of time was significant overall ($F(1, 227) = 14.41, p = .0002$) indicating that on average, participants increased in the number of short interchanges they used. However, the sites (VU and UCLA) were significantly different at entry ($F(1, 227) = 10.20, p = .0016$) and there was a significant interaction between site and time ($F(1, 227) = 9.21, p = .0027$) indicating that participants from VU used significantly more short interchanges at entry and did not increase significantly over the course of intervention ($t(227) = .55, p = .57$), while participants from UCLA used fewer short interchanges at entry and did increase significantly over the course of intervention. Participants at VU used approximately 5.41 more short interchanges at entry than participants at UCLA, but increased at a rate of only .12 interchanges per month of treatment. Participants at UCLA increased at a rate of 1.05

interchanges per month. Figure 4 shows the frequency of short interchanges for all participants across time, by site. Figure 5 shows the growth models for short interchanges by site.

Figure 4

Frequency of Short Interchanges – Participant Data

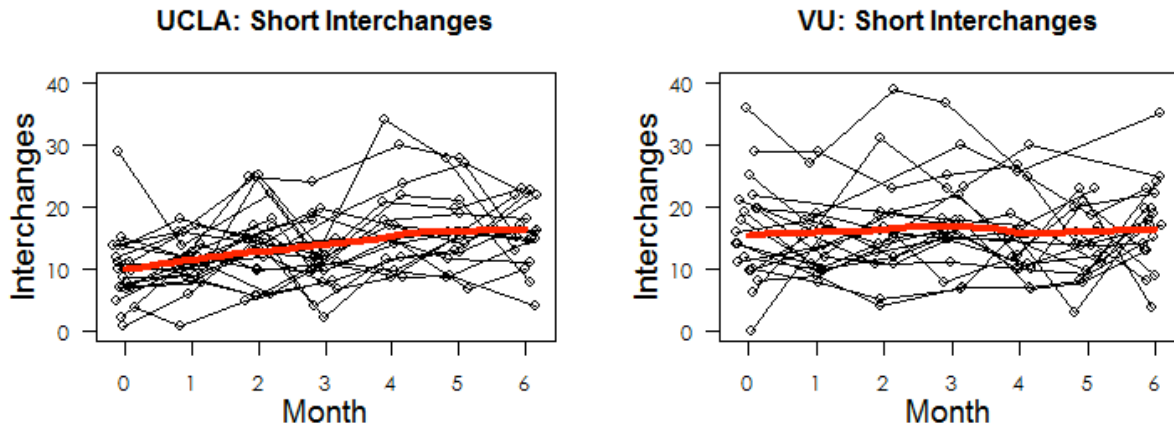
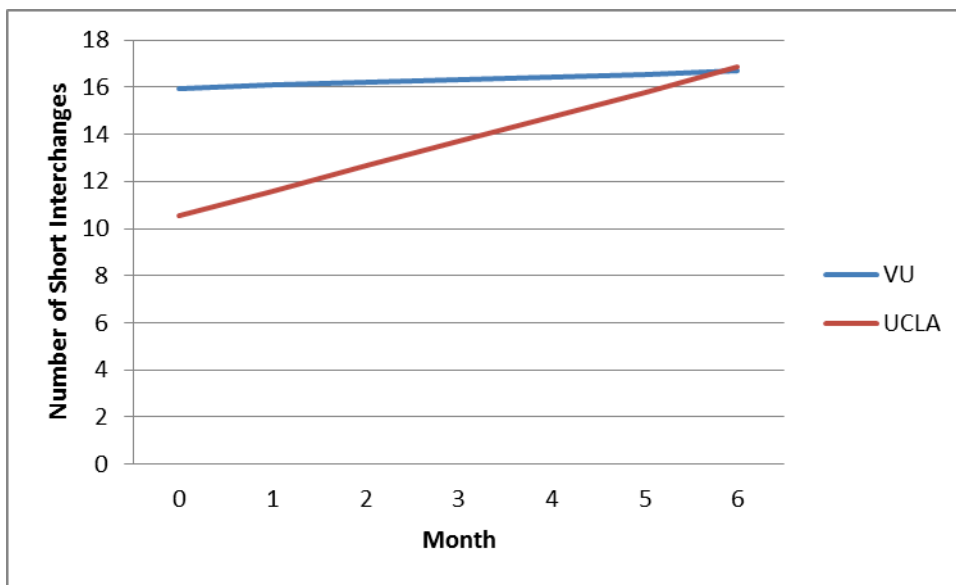


Figure 5

Frequency of Short Interchanges – Growth Model



Long interchanges. In the model for frequency of long interchanges, there was no main effect of site and no interactions with site so it was not included. The model for long interchanges was:

$$\text{Long Interchanges}_{ij} = \alpha_0 + \alpha_1 \text{time}_{ij} + \alpha_2 \text{treatment}_i + \alpha_3 (\text{time} \times \text{treatment})_{ij} + \beta_i + \epsilon_{ij}$$

Table 10

Linear Mixed Model Results of the Frequency of Long Interchanges Across Time

Effect	Estimate (SE)	DF	<i>t, F</i>	<i>p</i>
Intercept	4.34 (.76)	40	<i>t</i> = 5.70	<.0001
Time (Ref: AAC)	.89 (.14)	227	<i>t</i> = 6.34	<.0001
Treatment Group (Ref: AAC)	-1.29 (1.08)	1, 227	<i>F</i> = 1.43	.23
Time x Treatment Group (Ref: AAC)	-.43 (.20)	1, 227	<i>F</i> = 4.54	.03

Within this model the intercept was free to vary while the slope was fixed. The effect of time was significant overall ($F(1, 227) = 44.76, p < .0001$), indicating that on average, all participants increased in the number of long interchanges they used. There was a significant interaction between treatment group and time ($F(1, 227) = 4.54, p = .03$) but no main effect of treatment group ($F(1, 227) = 1.43, p = .23$), indicating that the treatment groups were not significantly different at entry but were significantly different in the rate that they changed over time. On average, participants in the JASP-EMT group increased at a rate of 0.46 interchanges per month, while participants in the JASP-EMT +AAC group increased at a rate of 0.89 interchanges per month. Figure 6 shows the frequency of long interchanges for all participants across time, by treatment group. Figure 7 shows the growth models for long interchanges by treatment group.

Figure 6

Frequency of Long Interchanges: Participant Data

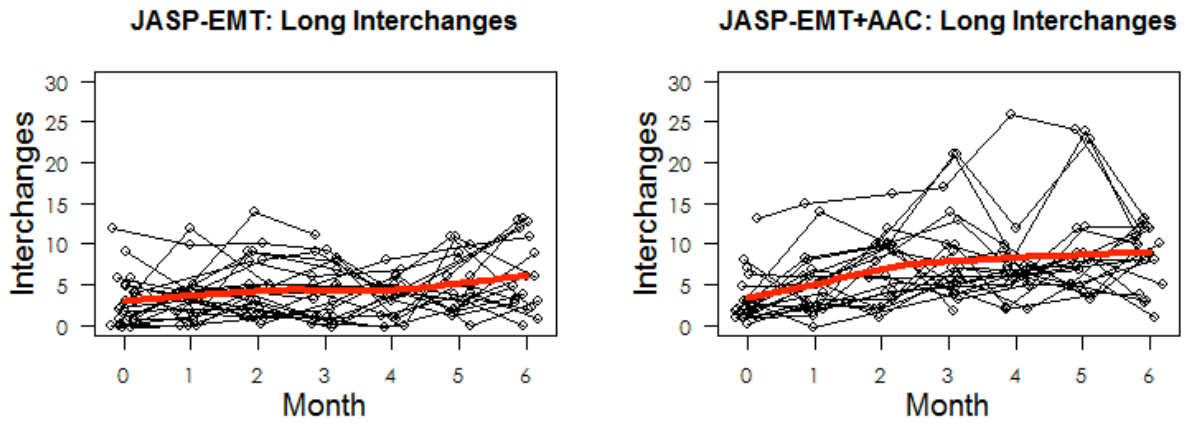
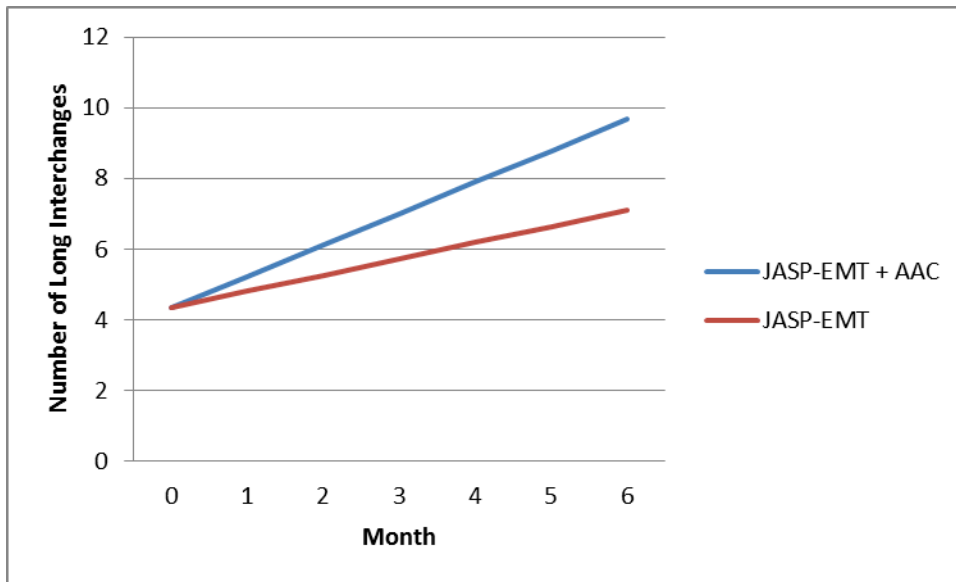


Figure 7

Frequency of Long Interchanges: Growth Model



Aim 3: Examine predictors of communication in minimally verbal children with autism over the course of a six-month intervention.

3.1 Examine chronological age, non-verbal mental age, receptive language, ADOS score and joint engagement as predictors of communication interchange growth.

First, the multi-level models for short and long interchanges were expanded to include predictors. Predictors were time fixed and were included at level two of the models.

Chronological age, non-verbal mental age, receptive language, ADOS total score and joint engagement (JE) were included in the models as predictors. Time fixed predictors in multi-level growth models represent the relationship between a predictor and an outcome over time.

Second, linear regression was used to test the strength of these predictors in predicting the frequency of short and long interchanges at exit (month 6), over and above the frequency of short and long interchanges at entry (month 0).

Short interchanges. In the model for frequency of short interchanges, chronological age, non-verbal mental age, receptive language and joint engagement were not significant and so were not included in the final model. There was no main effect of treatment group and no interactions with treatment group. The final model for short interchanges was:

$$\text{Short Interchanges}_{ij} = \alpha_0 + \alpha_1 \text{time}_{ij} + \alpha_2 \text{site}_i + \alpha_3 (\text{time} \times \text{site})_{ij} + \alpha_4 \text{ADOS}_i + \beta_i + \epsilon_{ij}$$

Table 11

Linear Mixed Model Results of the Frequency of Short Interchanges Across Time Including the Effect of ADOS Score

Effect	Estimate (SE)	DF	<i>t</i> , <i>F</i>	<i>p</i>
Intercept	25.12 (3.01)	39	<i>t</i> = 69.72	<.0001
Time (Ref: VU)	.13 (.22)	227	<i>t</i> = .59	.55
Site (Ref: VU)	-5.61 (1.56)	(1, 227)	<i>F</i> = 12.89	.0004
Time x Site (Ref: VU)	.90 (.30)	1, 227	<i>F</i> = 8.70	.004
ADOS Score	-.47	1, 227	<i>F</i> = 10.82	.001

Within this model, the intercept was free to vary while the slope was fixed. Vanderbilt University (VU) was set as the reference group. ADOS total score was a significant predictor of total number of short interchanges ($F(1, 227) = 10.82, p = .0012$), indicating that a higher total ADOS score was associated with fewer short interchanges across time. On average, each point increase in ADOS score was associated with 0.47 fewer short interchanges per session.

Linear regression was used to test the strength of ADOS score as a predictor of frequency of short interchanges at exit (month 6), controlling for the effect of frequency of short interchanges at entry (month 0). ADOS score was a significant predictor ($B = -.58, t = -3.00, p = .005$) of the frequency of short interchanges at exit, while the frequency of short interchanges at entry did not have a significant effect. ADOS score accounted for 16% of the variance in frequency of short interchanges at exit ($R^2 = .16, F(1, 34) = 8.93, p = .005$).

Long interchanges. In the model for frequency of long interchanges, chronological age, non-verbal mental age, receptive language and ADOS score were not significant and so were not

included in the final model. There was no main effect of site and no interactions with site. The final model for long interchanges was:

$$\text{Long Interchanges}_{ij} = \alpha_0 + \alpha_1 \text{time}_{ij} + \alpha_2 \text{treatment}_i + \alpha_3 (\text{time} \times \text{treatment})_{ij} + \alpha_4 \text{JE}_i + \beta_i + \epsilon_{ij}$$

Table 12

Linear Mixed Model Results of the Frequency of Long Interchanges Across Time Including the Effect of Joint Engagement

Effect	Estimate (SE)	DF	<i>t</i> , <i>F</i>	<i>p</i>
Intercept	2.60 (.88)	39	<i>t</i> = 8.76	.005
Time (Ref: AAC)	.88 (.14)	227	<i>t</i> = 6.27	<.0001
Treatment Group (Ref: AAC)	.71 (1.01)	1, 227	<i>F</i> = .5	.48
Time x Treatment Group (Ref: AAC)	.43 (.20)	1, 227	<i>F</i> = 4.57	.03
Joint Engagement	.47 (.14)	1, 227	<i>F</i> = 11.12	.001

Within this model the intercept was free to vary while the slope was fixed. JE was a significant predictor ($F(1, 227) = 11.12, p = .0010$), indicating that more time spent jointly engaged during the first intervention session was associated with more long interchanges across time. On average, each additional minute spent jointly engaged in routines in the first session was associated with 0.47 more long interchanges per session.

Linear regression was used to test the strength of JE as a predictor of frequency of long interchanges at exit (month 6), controlling for the effect of frequency of long interchanges at entry (month 0). JE was a significant predictor ($B = .63, t = -2.91, p = .006$) of the frequency of long interchanges at exit, while the frequency of long interchanges at entry did not have a significant effect. JE accounted for 20% of the variance in the frequency of long interchanges at exit ($R^2 = .20, F(1, 34) = 8.49, p = .006$).

3.2 Examine frequency of early communication interchanges as a predictor of expressive language change.

Linear regression was used to test if frequency of interchanges at entry predicted number of socially communicative utterances (SCU) used in the language sample at exit. Data were first evaluated to ensure that they met the assumptions of linear regression (linearity, independence, homoscedasticity and normality). The data appeared to be normally distributed and was not transformed. Short interchanges at entry, long interchanges at entry, SCU at entry, number of different words (NDWR) at entry, non-verbal mental age and ADOS score were included as predictors in the model. Variables were included stepwise. Short interchanges at entry, SCU at entry, non-verbal mental age and ADOS score were not significant predictors of SCU at exit. Both frequency of long interchanges and NDWR at entry were significant predictors of SCU at exit.

Table 13

Linear Regression Results of the Effect of Number of Different Word Roots and Frequency of Long Interchanges on Socially Communicative Utterances

Predictor	<i>B</i>	<i>SE B</i>	β	<i>t</i>	<i>p</i>	<i>R</i> ²
Step 1						.24*
Entry long interchanges	5.45	1.57	.49	3.47	.001	
Step 2						.50*
Entry long interchanges	3.18	1.39	.24	2.29	.03	
Entry NDWR	1.39	.31	.55	4.43	< .001	

* $p < .001$

Entry frequency of long interchanges explained a significant proportion of the variance in exit SCU ($R^2 = .24$, $F(1, 39) = 12.06$, $p < .001$). Entry frequency of long interchanges and entry

NDWR together explained a higher proportion of the variance in exit SCU ($R^2 = .50$, $F(2, 38) = 18.69$, $p < .001$).

Discussion

This study documented the communication skills of minimally verbal children with autism using in depth observation and coding that focused on how participants engaged in reciprocal communication interchanges with an adult partner. There were three main findings. First, children were noted to repair their communicative utterances using multiple strategies and these repairs were usually successful. Although repairs were present in a proportion of children, these did not increase over intervention. Second, children engaged in communication interchanges for a variety of communicative functions, and these interchanges increased over time in terms of frequency, length and the proportion that were initiated by the child. Third, children's level of joint engagement was positively related to their use of long interchanges, and frequency of long interchanges at the beginning of intervention predicted spoken language outcomes at the end of the study. These findings highlight the relationship between communication and social skills, as well as the need to look beyond discrete linguistic skills to meaningfully characterize the communication abilities of minimally verbal children with autism.

Communication Repair

Communication repair is a skill that emerges over the course of typical development, and requires detecting that the communication partner has failed to understand the message, then persisting in the communication interchange to rectify that misunderstanding. In this sample, 55% of the children engaged in communication repair at least once. About half of those children (29% of the sample) engaged in repair two or more times within the session segments that were transcribed and coded. At each time point, the majority of the repair episodes were successful,

meaning that the adult ultimately understood the child's message. The participants used a variety of strategies in accomplish repair, including repetition, substitution, augmentation and negation. Repetition was the most common strategy, followed by augmentation. This is in contrast to Keen (2005) who reported that in a sample of six preschool age minimally verbal children with autism, the most common repair strategies were repetition and substitution. The children in the current study were older and had a higher language level on average than the participants in Keen (2005), which may account for the difference in repair strategies observed.

The rates of repair were not observed to change over time in this study. There are a variety of factors that may have contributed to this fact. First, in the JASPER-EMT intervention, the therapist consistently follows the child's attention focus, responds to all child communication attempts and uses the child's interests to build consistent play routines. Given this responsive and predictable environment, there may have been few occasions of misunderstanding that required repair. Second, given that communication repair occurred at low frequency, coding only 10 minutes of a single intervention session at each time point may have been inadequate to capture a representative sample of repair episodes. Finally, six months may simply be too short a period of time for children to show growth in their ability to engage in communication repair.

This study included a much larger sample size than previous research documenting communication repair in minimally verbal children with autism. Although repair episodes occurred at relatively low frequency, it is an important contribution to the literature to document that some minimally verbal children with autism do engage in repair, and that they are able to use multiple strategies to do so.

Communication Functions

The children in this study used interchanges for multiple communicative functions. In addition to negotiating activities, negotiating possession of objects and establishing mutual attention, children engaged in communicative interchanges for the purpose of discussing a joint focus of attention. This comprised about 40% of their interchanges and is similar to the rates for typically developing 32-month-old children, as reported by Snow et al. (1996). It is important to note that the children in the Snow et al. sample were observed during unstructured parent interactions, while the children in this study were engaged in an intervention specifically designed to support their joint engagement with an interventionist. While there is undoubtedly a large effect of that supportive environment on the high rates of Discuss Joint Focus of Attention within this sample, it is still significant that the participants spent nearly half of their time engaged in interchanges that did not serve a requesting purpose. This highlights the fact that minimally verbal children with autism, despite having limited linguistic repertoires, can engage in social communication and that this ability may be supported by using specific intervention strategies to boost engagement. This is an important contribution to the literature, as most research on communication intervention for minimally verbal children with autism focuses on requesting language.

Communication Growth

The children in this study demonstrated growth in their use of communication interchanges over time. Their interchanges increased in frequency and length, as did the proportion of interchanges initiated by the child. At the beginning of intervention, participants initiated approximately 60% of the communication interchanges with their interventionist. This increased to 70% by the end of the six-month intervention. This is an important finding given

that the majority of language intervention for this population focuses on responding to prompts. The JASPER-EMT intervention used in this study emphasizes giving the child the opportunity to initiate, followed by the therapist quickly responding to and following that initiation. Given that supportive environment, the participants in this study were able to initiate the majority of the communicative interchanges in the session.

The length and frequency of communication interchanges also increased over the course of intervention. Overall, children were engaged in communication more often over time and sustained that communication for longer periods. Although there were more short interchanges than long at each time point, the number of long interchanges increased at a faster rate. This is significant, given the clinical importance of not only initiating and responding to communication, but sustaining engagement in communicative interactions.

Having access to an AAC device and being exposed to modeling on the AAC device was associated with faster growth over time in the frequency of long interchanges, compared to the group who received JASP-EMT without the addition of an AAC device. In the context of the JASP-EMT intervention, the additional support of the AAC device appears to enhance the ability of minimally verbal children with autism to engage communicative interchanges more frequently. There are a variety of possible explanations for this effect. One is that the AAC device is novel and interesting to the children, and acts as an additional draw to keep their attention on the communication interaction with the adult. Another possibility is that the presence of the AAC device lowers the difficulty level for communicating enough to increase rates of initiating and responding, leading to more frequent communication interchanges. It is also possible that hearing language modeled both by the adult's spoken words and the AAC device boosts children's rates of communication. More analysis and more research are needed to

more fully understand the effects of including the AAC device within the JASP-EMT intervention.

Predictors of Communication

A variety of interesting relationships emerged in examining the predictors of communication interchanges and expressive language outcomes. Frequency of short interchanges (2-3 turns in length) was uniquely predicted by total ADOS score. The two variables had an inverse relationship, indicating that children with more significant autism characteristics engaged in fewer short interchanges across time. This could indicate that these children are less likely to respond to adult prompts and elicitation bids, as short interchanges were more likely to be initiated by the adult than long interchanges. In contrast, frequency of long interchanges (4+ turns in length) was best predicted by time spent jointly engaged in play during the first intervention session. These relationships highlight the important interaction between social and communication skills. Joint engagement was not a significant predictor of short interchanges, indicating that these single response communication exchanges are not related to engagement in the same way that sustained communication interchanges are. Instead, joint engagement is uniquely predictive of children's ability to engage in communication interchanges consisting of multiple turns back and forth, whereas short interchanges are related to ADOS score. Participating in short interchanges may be more indicative of a child's overall autism symptomatology, while participating in long interchanges is specifically related to a child's ability to jointly engage with a communicative partner.

In addition to predictors of communication interchanges, this study also examined early communication interchange use as a predictor of later expressive language. The frequency of long interchanges at entry was a significant predictor of the number of socially communicative

utterances children used six months later, while the frequency of short interchanges at entry was not significant. This again highlights the unique importance of sustained communication interchanges over short exchanges in which the child may take only a single turn. Within this sample of minimally verbal children with autism, the frequency of long interchanges at the beginning of intervention was significantly related to children's rate of expressive communication at the end of intervention. More research is needed to further explore this relationship, but it is plausible that engaging in sustained communication interchanges gives children the exposure necessary to increase their expressive language abilities. This has significant implications for intervention, especially given that many current interventions for this population focus on discrete language skills delivered in response to a prompt (for example, requesting a desired item that is being offered), rather than on developing sustained communicative interactions. If in fact sustained communicative interactions are uniquely suited to encourage expressive language development and uniquely related to joint engagement, they should be a primary target of intervention efforts.

Limitations

This study has several limitations that should be addressed. First, the fact that only 10-minute clips of single intervention sessions were transcribed and coded at each time point may have reduced the stability of the data. Including additional data at each time point might have resulted in more stable data, thus increasing statistical power. In addition, interchange types that occurred at very low frequency (including repair episodes) may not be accurately represented. Second, the sample size in this study likely limited the statistical power to detect predictors in the multi-level models. Although the sample size was relatively large for this population, a larger sample may have allowed for detection of multiple predictors per model. Finally, this study did

not include a control group. Although the two treatment conditions can be compared to each other, the absence of a control group makes it impossible to determine how communication growth in these participants would have differed from similar children not participating in intervention.

Future Directions

This study made several important contributions to the literature. First, it focuses on minimally verbal children with autism over the age of five, which is a population greatly underrepresented in research. Using an in depth coding system, this study documented communication abilities, including communication repair, in a relatively large sample of participants. This information increases our understanding of how these children use communication skills to engage with a partner, and how that ability changes over time. The findings from this study also support research demonstrating the important link between joint engagement and communication development, and highlight the need to include sustained communication interchanges as a target of intervention for minimally verbal children with autism. In order to follow up on the findings from this study, a variety of relationships should be further explored. First, future research should investigate the relationships among joint engagement, sustained communication interchanges and expressive language. The predictive relationships found in this study should be further explored in terms of mediating and moderating relationships. Second, more research is needed to understand the role of the AAC device in boosting children's communication engagement. Specifically, it should be determined if use of the AAC device by the child is necessary for this effect to occur, or if simply hearing additional language modeling produced by the device is sufficient. Finally, similar analyses of communication growth should be conducted in a sample of children who are not undergoing

intervention to allow for general characterization of communication development in minimally verbal children with autism.

Appendix A: Interchange and Repair Transcript Coding

Interchanges:

coded on comment line at end of each interchange

Length:

[#] = length (# of turns), always count from first CHILD turn

Initiator:

[cici] = child initiated communication interchange

[aici] = adult initiated communication interchange (includes elicitations such as time delay)

Function:

[ema] = establish mutual attention (get help). Establishing mutual attention, calling other's attention to something of interest or asking for help. Happens outside the context of a routine (with the exception of asking for help).

[nia] = negotiate immediate activity. Negotiate the initiation, continuation, and/or ending of joint activities. To allocate roles, moves and turns in joint activities.

[npo] = negotiate possession of an object (request/reject). Requesting or rejecting objects. Negotiating who can have the object or when.

[dja] = discuss joint focus of attention. Communicate about something in the environment that both participants are attending to (not requesting).

[dtf] = discuss thoughts and feelings. Communication about internal state, such as being hungry or tired.

[dfw] = discuss fantasy world. Communication about fantasy play, not concrete play actions.

[oit] = other interchange type. Interchange has a clear function that is not included in this list.

[uit] = unknown interchange type. Function of the interchange cannot be determined.

[cvc] = clarification of verbal communication (repair). See additional codes below.

Repair:

Success:

[rs] = repair successful, adult acknowledges that they understand the child's message

[ra] = repair abandoned, adult does not understand the child's message but the child discontinues the repair

Strategy (coded on each child turn in repair):

[rep] = repetition, child repeats exact same communication

Example:

Child: ball.

Adult: {gives block} block.

Child: ball.

Adult: , oh want ball {gives ball}!

[sub] = substitution, child substitutes different communication (e.g. first says "want", then says "ball").

Example:

Child: want.

Adult: want block?

Child: ball.

Adult: oh want ball {gives ball}!

[aug] = augmentation, child augments previous communication with something new (e.g. first says "ball", then says "ball" and points).

Example:

Child: ball.

Adult: want block?

Child: ball {points to ball}.

Adult: oh want ball {gives ball}!

[neg] = negation, child rejects adult turn without offering any additional information (e.g. says “no” or shakes head).

Example:

Child: want.

Adult: want block?

Child: no.

Adult: oh want ball {gives ball}!

Appendix B: Supplementary SALT Transcription Guidelines

Sounds:

- a) Some sounds are transcribed with brackets while others are not.
 - a. Refer to the list found in SALT guidelines.

1. Self-stimulatory/perseverative communicative behaviors:

- a) Whenever a child vocalizes or performs an action that seems to be scripted or self-stimulatory, transcribe with an [s] code.
 - a. Example: C I'm so sad [s].
 - b. Example: C {singing Jingle Bells} [s].

2. XXX versus vocalization:

- a) XXX is used to transcribe unintelligible utterances if the child has definite communicative intent and is clearly using or trying to use language but the words cannot be made out due to apraxia, low volume, mumbling, etc.
 - a. Example: C XXX [s].
=child inflection/intonation indicate he's reciting movie lines, but transcriber cannot make out the words.
 - b. Example: C XXX.
=child says sentence but transcriber cannot make out words
- b) {vocalization} is used when words are not being intentionally communicated.
 - a. Example: C {vocalization} [s].
=stimmy noises.
 - b. Example: C {vocalization}.
=protesting toys.

- c) Both vocalizations and unintelligible utterances can be scripted or not scripted.
 - a. Use the [s] code with caution. In SALT analysis, everything given an [s] code is completely excluded from analysis.

3. AAC device:

- a) If the child only activates the device, transcribe the activation and device output.
 - a. Example: C {pushes “dog” on AAC device} Dog.
- b) If the child activates the device and says the word (“dog”) along with output, it will be transcribed the same as above.
 - a. Example: C {pushes “dog” on AAC device} Dog.
- c) If the child repeatedly activates the device because he is curious or learning about the device, transcribe with an [s] code.
 - a. Example: C {pushes buttons on AAC device} [s].
= child presses every button on screen.
- d) If the child repeatedly activates one button on the device as a self-stimulatory behavior, transcribe with an [s] code.
 - a. Example: C {repeatedly pushes “dog” on AAC device} [s].

4. Gestures that are transcribed:

- a) Shows object or holds up choice of two toys.
 - a. A {shows toy}.
- b) Gives object .
 - a. A {gives block}.
 - b. Only transcribe when it is clearly communicative, as indicated by:
 - i. Holding the object in front of the child and then giving.

- ii. Saying something while giving (i.e. here).
 - iii. Making eye contact with the child.
- c) Points to an object
- a. A {points to doll}.

5. Repetitive speech:

- a) If the adult or child repeats an utterance with less than a 2 second pause in between, transcribe the repetition.
- a. C (I want) I want.
- b) If the adult or child repeats an utterance with more than a 2 second pause in between, transcribe as separate utterances.
- a. Example:
 - i. C I want.
 - ii. C I want.

6. Rote phrases:

- a) Use the underscore to connect words that the child consistently combines in his speech
- a. Example:
 - i. C all_done
 - ii. C (Potty_please potty_please) potty_please.
 - iii. C I_want toy.
 - iv. C Can_I_have car?
 - v. C You_ok?
- b) Do not underscore words that the child combines in different ways within a session.

- a. Example:
 - i. C I want car.
 - ii. C Want car.
 - iii. C {points to car} Car.

7. Proper nouns, titles of books, movies or songs:

a) Proper nouns, titles of books, movies or songs are transcribed as a single linked word.

- a. Example:
 - i. C I like winniethepooh.
 - ii. C We are going to missfuller/z school.

8. Counting, the alphabet, and singing

a) Counting, reciting the alphabet and singing are transcribed in brackets.

- a. Example:
 - i. C {counting}.
 - ii. C {singing}.
 - iii. C {saying ABCs}.

b) If the child counts/sings but then says a word after, transcribe counting/singing in brackets and the word outside the brackets.

- a. Example:
 - i. C {counting} car/s.

c) If the child counts/sings as scripted or self-stimulatory behavior, transcribe in brackets with an [s] code.

- a. Example: C {singing Sesame Street} [s].

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