COMMUNICATION COMPLEXITY, CODED LANGUAGE OUTCOME MEASURES, AND MINIMALLY VERBAL PRESCHOOL CHILDREN WITH ASD

By

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(Under the Direction of Jennifer Brown)

ABSTRACT

This study examined the communication complexity across school activities of three preverbal preschoolers with autism spectrum disorder (ASD). The three children wore Language Environment Analysis (LENA) Digital Language Processor (DLP) vests in their self-contained classroom throughout three school days. The LENA system recorded and analyzed through specialized speech algorithms the child's language environment. Identified segments of time that contained the most child vocalizations (CVs) per class activity (i.e., lunch, small group, large group, recess, and direct instruction) were subsequently manually coded for utterance type using a classification system assigning levels of complexity to the vocalizations. It was found that no one activity type elicited more frequent or complex preverbal communication for all participants, but specific individual speech profiles were identified. Future research replicating these and extending these procedures could support assessment and intervention planning for preschool students who are minimally verbal.

INDEX WORDS: Autism, Autism Spectrum Disorder, ASD, LENA, Preverbal, Minimally Verbal, Preschool, Communication, Communication Complexity

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B.S.Ed., The University of Georgia, 2017

A Thesis Submitted to the Graduate Faculty of the University of Georgia in Partial Fulfillment of the Requirements for the Degree

MASTER OF ARTS

ATHENS, GEORGIA

2019

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Electronic Version Approved: April 2019

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INTRODUCTION

Autism spectrum disorder (ASD) is characterized by persistent deficits in the areas of social communication and restrictive and repetitive behavior across multiple contexts (*Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition*, 2013). Social communication deficits include difficulty in using non-verbal and verbal means of communicating for a variety functions matched to the social situation. Despite the core deficit of social communication, individuals with ASD present with a range of structural language skills (i.e., sentence structure and vocabulary). Some individuals with ASD have typical to advanced structural language skills and others have impaired structural language or are minimally verbal.

Minimally Verbal Children with ASD

Infraphonological theory states that most children travel through stages of development from preverbal communication such as quasi-vowels and squealing to more "speech-like" canonical syllables (consonant-vowel [CV] syllables with adult-like intonation contour) to English words (Woynaroski et al., 2016). Children with ASD, however, can have high variability in the staging of their language development. Some children with ASD may stay in the preverbal stage for differing amounts of time (Rose, Trembath, Keen, & Paynter, 2016).

Children with ASD who use few spoken words and minimal to no word combinations have been described with different terms such as nonverbal, low verbal, preverbal, prelinguistic, and nonvocal (Keen, Meadan, Brady, & Halle, 2016; Lord, Risi, & Pickles, 2004; Mody, 2016; Tager-Flusberg & Kasari, 2013). Tager-Flusberg et al. (2009) defined spoken language benchmarks for characterizing expressive language in young children with ASD. The

benchmarks are defined in four phases: preverbal communication, first words, word combinations, sentences, and complex language. Kasari, Brady, Lord & Tager-Flusburg (2013) described minimally verbal as children who have no spoken words or phrases to children with up to 30 single words and a few scripted or repetitive phrases along with a low rate of using verbal words. Children meeting this minimally verbal category would include those at the preverbal communication and first words benchmark phases with some emergence into the word combinations benchmark phase (Tager-Flusberg et al., 2009).

Minimally verbal children with ASD communicate primarily with preverbal communication acts (e.g., vocalizing speech sounds not recognized as words, or non-speech sounds). Vocalizing and gesturing are just a few of the different ways a child with preverbal communication skills could be communicating (Woynaroski et al., 2016). Some minimally verbal children communicate with functional, intentional words as well, but the quantity varies from child to child. Kasari and colleagues (2009) defined “minimally verbal” as a repertoire of twenty or fewer functional words. Rose (2009) used a similar definition in their study but concluded that minimally verbal children can have up to thirty functional words or phrases. Norrelgen and colleagues said minimally verbal children can use at least three words, but never or only sometimes two-word phrases (2015). However, it has been said that the exact number of functional words and phrases used to categorize a child as minimally verbal is primarily useful in research, rather than clinical settings (Kasari, Brany, Lord, & Tager-Flusberg, 2013). It is also important to note that most definitions of “minimally verbal” do not include echolalic or stereotypic utterances the child may have (Rose, Trembath, Keen, & Paynter, 2016). Even when these utterances take the form of words or phrases, it is difficult to differentiate if it is being used

functionally or solely for the purpose of self-stimulation. It is for this reason that they are excluded (Kasari, Brady, Lord, & Tager-Flusberg, 2013).

Measuring Speech and Language in Minimally Verbal Children with ASD

Minimally verbal children with ASD's communication skills can be evaluated through standardized measures as well as non-standardized measures. Standardized measures can be difficult to administer and/or score due to low verbal output, potential receptive difficulties, and attention/behavioral issues that can accompany ASD (Kasari, Brady, Lord, & Tager-Flusberg, 2013). In 2013, a team of researchers and experts in the field investigated assessment measures frequently used by SLPs when evaluating speech and language for minimally verbal children with ASD. Using criteria such as test validity, reliability, and the experts' experiences in assessing minimally verbal children with ASD, they recommended certain assessment methods as best practice for this population. It was determined that *the Peabody Picture Vocabulary Test-IV* (PPVT-IV) was the best standardized language measure for this population, and that other standardized language tests such as the *Preschool Language Scales – 5* (PLS-5), *Test of Early Language Development-3*, *Sequenced Inventory of Communicative Development-Revised, Reynell Developmental Language Scales-III*, and the *MacArthur-Bates Communication Development Inventories (CDI)* were best used "with some caution" (Kasari, Brandy, Lord, & Tager-Flusberg, 2013). It is important to note that a standardized test needs to align with the focus of the assessment. For example, the PPVT-IV is used as a measure of receptive vocabulary. If the purpose of the assessment were to examine generative expressive language, the PPVT-IV would not be appropriate despite its recommendation as procedurally sound with individuals with ASD.

Non-standardized measures are also valuable in assessing communication. Speech sound inventories are vital for accurately describing how an individual communicates. As many children with preverbal language skills are unable to complete a standardized speech measure requiring the repetition of whole words and sentences, Kasari and colleagues (2013) recommend compiling a speech sound inventory from spontaneous language sampling. In addition, language samples obtained through naturalistic observation were noted as best to assess the child's language abilities in conjunction with the PPVT (e.g., compiling a language use inventory).

Through teacher and SLP report and observation, the Communication Complexity Scale, Communication Matrix, Joint Attention Measures (JAMES) structured probes can also be used to assess the child's intentional communication (Kasari, Brandy, Lord, & Tager-Flusberg, 2013). The Communication Complexity Scale is a tool designed to assess an individual's communication forms and provide a summary score for the individual's overall communication. This scale was designed specifically to measure the communication of individuals with pre-symbolic or early symbolic communication skills (Brady et al., 2012). The Communication Matrix measures the communication of individuals functioning with pre-symbolic communication and even through augmentative/alternative modalities. The Matrix is completed online by parents and professionals, and the de-identified information is collected and stored in the site's database (Rowland, 2012). The JAMES structured probes are part of the Early Social Communication Scales (ESCS). The ESCS is a videotaped, structured observation assessment measure also intended for individuals with nonverbal communication skills (Mundy et al., 2013). Concurrent validity has been found between the Communication Complexity Scale and Communication Matrix, along with more frequently used measures such as *PLS-4* raw scores and *Mullen Scales of Early Learning* (Brady et al., 2012). Other parent/teacher report measures such

as the *Vineland Adaptive Behavior Scales-II* and the *Inventory of Potential Communicative Acts* were found to be acceptable in assessing language for preverbal children with ASD, but are better used in conjunction with other assessments with higher measures of validity (Kasari, Brandy, Lord, & Tager-Flusberg, 2013).

Researchers have devised systems of categorization for speech as well as non-speech communication to analyze communication samples in minimally verbal children or children at early speech and language development stages. Schoen and colleagues (2011) categorized non-speech vocalizations into categories of laughter, distress, squealing, growling and yelling, while Tager-Flusberg and colleagues (2009) created detailed benchmarks for "phase 1" (non-word) productions and "phase 2" (word) productions. These benchmarks include specific guidelines for components of language (phonology, pragmatics, etc.) and correspond with developmental norms and approximate ages (Tager-Flusberg et al., 2009).

Plumb and Wetherby (2013) divided utterances into transcribable/speech vocalizations, non-speech/non-transcribable vocalizations, and those that could not be determined. Transcribable vocalizations were categorized into four levels: level 1, in which the utterances contains a vowel or CV syllable containing /h/ or a glottal replacement; level 2, in which the utterance contains a single consonant or identical consonants; level 3, in which the utterance contains at least two consonants (excluding consonant clusters or a pair of cognates); and level 4, in which the utterance contains a consonant cluster. Non-speech utterances were categorized into laughs, sounds of distress, "atypical" (e.g., a yell, grunt, squeal, or growl), non-English speech sounds, single consonants and "other."

Coding Methods

Traditionally, manual phonetic transcription has been used to track the quality and quantity of a child's language. Since some children with ASD use preverbal communication and non-speech sounds to communicate, the coding of communicative behaviors is necessary to study their communication. Chiang and colleagues (2009) analyzed preverbal communication acts in minimally verbal children with ASD from preschool-age to sixteen years old. Video-recorded expressive communication acts were manually coded and categorized. An expressive communication act was defined by an attempt to convey information to a communicative partner. These communication acts were then categorized by mode (speech, aided AAC, and unaided AAC) and function (request, reject, greet, or comment) (Chiang et al., 2009).

Keen and colleagues also categorized children with ASD's verbal and nonverbal communication using function categories (requesting object, requesting action, attention to self, comments, social convention, reject/protest, responses, requesting information, and imitation) (Keen, Sigafoos, & Woodyat, 2005). Schoen and colleagues, rather, coded children with ASD's utterances as speech versus non-speech vocalizations, and then further classified non-speech vocalizations into the categories of laughter, distress, squealing, growling and yelling (Schoen, Paul, & Chawarska, 2011). However, with technological advances, automated analyses are increasingly used to characterize expressive communication.

Automated Vocal Analyses

Automated vocal analyses record and analyze speech samples automatically are an option for researchers and clinicians in assessing children's verbal communication. A number of studies have used a type of automated vocal analyses called Language ENvironment Analysis (LENA). LENA is a tool that records, categorizes, and analyzes speech samples. It filters out noise and

counts the number of adult words spoken to a child, number of vocalizations the child makes, and the number of times the child and adult engaged in a conversational turn.

The LENA system consists of a digital language processor (DLP) and a software program for analysis. The DLP records the child's speech sample across hours of naturally occurring activities and the software program uses specified algorithms to analyze the sample and provide estimates of child vocal production and adult utterances. LENA can be a powerful tool when it comes to reducing time and effort put into coding or manual transcription (Woynaroski et al., 2017). LENA can also provide children and their families more privacy in collecting naturalistic communication samples. When LENA automated analyses are used as outcome variables, the assessor (researcher or clinician) does not need to listen to the samples as is required in recording plus transcription/coding speech sample methods. LENA also minimizes the subjectivity or variability that manual transcription or coding software could entail. LENA decreases cost spent on obtaining the speech sample data in that fewer human hours go into preparing the sample (Yoder, Oller, Richards, Gray and Gilkerson, 2013). In one study utilizing LENA, it was reported that only thirty minutes was spent on obtaining each language sample (Woynaroski et al., 2017).

The LENA system analyzes the recordings by filtering and classifying the sound. Non-speech sound is classified as noise, TV/electronic sounds, or silence. Vocalizations are identified by a 300 millisecond pause before and after the utterance. These vocalizations are categorized as male or female adult speech, vocalization by the child wearing the DLP, and vocalizations by other children nearby. LENA generates three measures from the filtered sound: child vocalizations (CV), which include words, babbling, and other speech-related sounds, but exclude crying, burping, or other vegetative sounds; adult word count (AWC) words spoken to the child

or near the child by an adult, excluding media noise such as TV and radio or overlapping speech between the child and adult; and child turns (CT), which monitor the number of conversational turns between the child and any adults (given that the two respond to each other within five seconds) (Warren et al., 2009). An estimated mean length of utterance (EMLU) can also be generated using LENA's Automatic Vocalization Assessment (AVA); the AVA measure which compares the child's patterns of vocalization to a matched peer group. Vocal Productivity (derived from canonical syllable length), Interpreted Time Segments (which summarizes the processing results for the data contained within the original audio file), and developmental measures are also available (LENA: Closing the Word Gap). Reports of sound classifications are provided in reports generated based on user preference, including daily, hourly, and five-minute segments (Bredin-Oja et al., 2017).

LENA Measurement in Child Language Research

LENA has been used with a variety of ages and abilities in children (including those preschoolers with ASD) and in a variety of settings, such as school and home (Bredin-Oja et al., 2017). Children and adults who are Deaf, Hard of Hearing, multilingual, or who have ASD, Down syndrome, developmental disabilities, and social/emotional/behavioral disabilities have been included in the literature base. LENA has been used internationally in assessment and intervention research since research since 2006 (Wang, 2017). While research on LENA itself, LENA in schools, and LENA with children with ASD has been completed, very little exists in the current literature specifically pertaining to preschool settings and minimally verbal children with ASD using LENA technology. Although this population has not specifically been included in research with LENA, a number of precursor studies exist to set the stage for a study developed for this population.

Dykstra and colleagues (2012) used LENA to assess preschool children with ASD's language learning environments in the classroom over the course of a school year. The children were given the *Preschool Language Scale, Fourth Edition (PLS-4)*, the *Mullen Scales of Early Learning*, and the *Autism Diagnostic Observation Schedule (ADOS*). These children were referred to as having "varying verbal abilities." It was found that the child's vocalizations increased in frequency significantly from the beginning to the end of the school year. AWCs and CVs were significantly correlated to each other. It was also noted that the children with the highest cognitive impairments produced the fewest vocalizations in the classroom setting (Dykstra et al., 2012).

Burgess (2013) similarly studied preschoolers and school age children with ASD's language learning environments with LENA. This time, however, school as well as home environments were evaluated and compared. The children were tested with the *Preschool Clinical Evaluation of Language Fundamentals, Fourth Edition (CELF)* and the *Vineland Adaptive Behavior Scales*, and as a group were referred to as "language delayed." LENA was used to monitor the children's language environments, identifying 15-minute sections of the speech samples that contained the highest AWC. It was also found that child-oriented activities that foster language development were more likely to occur at home than at school, which may account for the higher mean length of utterance (MLU) and vocalization frequency found at home (Burgess et al., 2013).

Warren and colleagues used LENA to analyze language learning environments and vocalizations for children with autism, comparing them to a typically-developing control group. Participants were school-aged, and samples recorded by the DLP took place at home and in the classroom. These children were of varying language abilities. On average, children with autism

produced 26% fewer conversational turns and 29% fewer vocalizations in the classroom than their typically-developing peers. While this percentage may seem insignificant, the average number of missed conversational turns per day (146) would cumulate into a difference of 1,022 turns per week and 53,290 per year. Similarly, the average difference of 647 child vocalizations per day produced by the children with autism compared to the typically developing children would result in 4,529 per week and 236,155 per year (Warren et al., 2010).

Irvin compared LENA's AWC measure with the classroom learning environment characteristics. The children in these preschool classrooms were children with ASD of "varying verbal abilities." Irvin found that AWC was correlated with a child's cognitive ability and inversely related to teacher burnout (Irvin et al., 2013). Similarly, Warlaumont used LENA to assesse adult-child interactions with LENA. This study, however, took place in a variety of settings. Subjects were babies from eight months old to preschool-age children; one group of children with ASD and one control group of typically-developing children. Overall, Warlaumont found that children with ASD's vocalizations were less likely to result in a conversational turn with an adult, likely because a smaller proportion of their utterances were speech-like (Warlaumont et al., 2014).

Communication Across Classroom Activities

While a number of studies have used automated analyses and coding measures to assess minimally verbal children with ASD in preschools within the school setting (Burgess, Audet, Harjusola-Webb, 2013; Chiang, 2009; Dykstra et al., 2013; Irvin, Hume, Boyd, McBee, & Odom, 2013; Warlaumont, Richards, Gilkerson, & Oller, 2014; Warren et al., 2010), only a few have measured expressive output within different classroom activities (e.g., circle time, snack time, individual intervention time, etc.) (Chiang, 2009; Irvin, Hume, Boyd, McBee, & Odom,

2013). However, the purpose of these studies was not to compare the frequency and/or type of communication used by the children during these different classroom contexts. Irvin's aim was to solely focus on LENA's AWC measure to draw broader conclusions about language learning environment, and Chiang's purpose was to code utterances for mode and function. Neither study included specific classroom activities as a variable.

However, other studies concerning the communication of preschool-aged, minimally verbal children with ASD have examined the children's output in contexts similar to contexts found in special education classrooms. In particular, one-to-one instruction time and low adult-child ratio contexts have been examined. Irvin and colleagues (2013) found the LENA AWC measure to be negatively correlated with adult-child ratio. This could be significant because AWC has been shown to correlate with the LENA CV measure (Dykstra et al., 2013). Warren found higher CV measures while the children were in one-on-one therapy sessions when compared to CV measures collected while in their classrooms. Similarly, Burgess (2013) found this population to exhibit higher MLU and CV measures at home, where the adult-child ratio is low. Warlaumont and colleagues (2014) asserted that a child's vocalization is more likely to be speech related if the child's previous vocalization had received an immediate adult response, and that a low adult-child ratio is more likely to garner these responses. They claimed that a social feedback loop between child and caregiver promotes speech development in this way.

To determine if adult-child ratio and other characteristics of certain classroom activities truly are factors in eliciting more communication from preverbal preschool children with ASD, more research is required. As of yet, no work has been done to investigate specifically as to when this population is most likely to communicate verbally within the school day, and no studies have investigated as to when their most complex (though perhaps not most frequent)

communication takes place within the school day. In 2013, Dykstra and colleagues called for more research to investigate into how specific contexts across the school day relate to communication in this population.

Purpose

Exploring the frequency and complexity of minimally verbal children with autism will add to clinical and research knowledge. Discovering when and where these children produce their most frequent and most complex preverbal communication in the classroom will be important for making future diagnostic and therapeutic decisions. Therefore, the focus of this project is to code speech acts from the classroom speech samples of minimally verbal preschoolers with ASD to discover how the frequency and complexity of their utterances differ during different times throughout the school day.

METHOD

Participants

Participants included three preschool children (two females; one male). See Table 1 for demographic information; pseudonyms are used. All participants had a diagnosis and/or education eligibility of autism spectrum disorder (ASD) and were considered “minimally verbal” by special education teachers and other professionals. The teachers reported that each of the children used few spontaneous generative words; they either imitated words or primarily used consonant-vowel vocalization combinations. The children were preschool students at a public school in the Southeastern United States and received special education services in one of its self-contained classrooms.

Table 1: Participant Demographic Information

Participant	Age	Race/Ethnicity	Home Language	Special Education Eligibility
Aiden	4 years, 2 months	African American	English	Autism
Ana	3 years, 11 months	White, Hispanic	Spanish	Autism
Isabella	4 years, 5 months	African American	English	Autism

Materials and Measures

Participants’ vocalizations were recorded by Language Environment Analysis’s Digital Language Processor (LENA DLP), a small recorder embedded in a LENA-designed vest they will be given to wear each day. LENA recorded the child’s language over a given period of time and used Advanced Data Extraction Software (ADEX) to generate information on the child’s

own utterances as well as the language learning environment the child was in. After the language sample was recorded, LENA used ADEX to analyze the sample. (LENA: Closing the Word Gap).

Coded Speech Production

Portions of the LENA recording samples were coded for child speech acts according to a coding manual adapted from the speech analysis procedures of Tager-Flusberg et al. (2009) and Plumb and Wetherby (2013); see Appendix A for coding procedures and definitions. Frequencies of each type of speech act were calculated.

Procedures

Data collection. Participants wore the LENA DLP on their person while at school for three days to gather a continuous language sample lasting the entirety of each school day. The children wore the DLP in the vest designed by LENA that ensured correct positioning of the microphone close to the child's head. The complete recording was analyzed with the LENA software system. The investigators extracted two 5-min audio segments from each of five targeted class activities yielding ten 5-min audio files per day for a total of thirty 5-min audio files each day across participants. The targeted class activities included: small group, large group, lunch, recess, and direct instruction. From the LENA automated analysis CV frequency data, the two highest CV counts from each activity time were selected. The audio files were uploaded to the Noldus The Observer software for manual coding according to the coding procedures described below and in Appendix A. Total minutes of audio files that were manually coded for speech acts: 50 minutes per day coded for each child, 150 minutes total coded for each child, and 450 minutes coded for the entire study (see Appendix B).

Coded Speech Analysis. The 10 segments per child, per day, uploaded to Noldus The Observer were coded by vocalization type. A vocalization must be preceded and followed by at least one second of silence to count as a discrete utterance (adapted from criterion from Plumb & Weatherby, 2013). First level categorization included determining if the vocalization is "phase 1" (non-word productions) or "phase 2" (word productions) based on adapted definition from Tager-Flusberg et al., 2009. The second level of categorization further specified the vocalization within the broad type from level 1 categorization. Phase 2 vocalizations were subsequently classified as speech sound or transcribable vocalizations (TV), non-speech sound or non-transcribable vocalizations (NTV), and vocalizations that cannot be determined as either (CBD). The TV category was also subdivided into four levels depending on the speech sounds used (see Appendix A). Phase 2, TV Levels 1-4, NTV, and CBD vocalization categories were considered mutually exclusive (adapted from criterion by Plumb & Weatherby, 2013). Frequency of each coded speech act type was calculated for data analysis (See Figure 4 and Appendix B). A second trained rater manually coded 20% of samples to calculate percent agreement reliability.

Analyses

To answer the research question, the investigator computed the total number of utterances corresponding to each level of complexity within each activity time. Descriptive statistics were used to make comparisons between participants, activity types, and environments within the classroom in which these recordings took place.

Interrater Agreement. Before beginning data analysis, the author trained a second coded on the coding procedures. Segments were dual coded until both coders reached agreement. Disagreements were discussed and revisions were made in the coding manual to address questions and concerns to improve clarity. Two coders coded twenty percent of the 5-min audio

segments (n=18, n=6 per participant) for reliability purposes. Percent agreement of coded utterances was calculated. Percent agreement ranged from 64.5% to 73.4% agreement for total combined NTV and TV variables, respectively. Level 1 utterances, the highest frequency utterances, yielded percent agreement of 89.8%.

RESULTS

The purpose of this study was to answer the following research questions: when audio files collected from high CV intervals (across five school activities for three days involving three participants) were coded for specific types of preverbal speech acts, when did the most frequent and most complex preverbal communication occur? Descriptive statistics were used to characterize the children's utterances and to compare across activities. Results are presented across the following categories: utterance type, activity type, and participant.

Utterance Types

Transcribable (TV) Utterances. When all TV utterances across all segments coded were totaled, the most frequently produced type of TV utterance was Level 1 (i.e., single vowel or CV syllable containing /h/ or a glottal replacement). Frequency had an inverse relationship with complexity, with Level 2 (i.e., syllable containing one consonant) and Level 3 (i.e., syllable containing two different consonants, excluding consonant blends and cognate pairs) determined as second and third most produced TV utterances. Phase 2 (i.e., English word) utterances were produced least frequently. Level 4 (i.e., utterances containing a consonant cluster), were not produced at all, as no child produced across any of the segments coded. It was found that the group spoke fewer Phase 2 utterances than Phase 1 utterances.

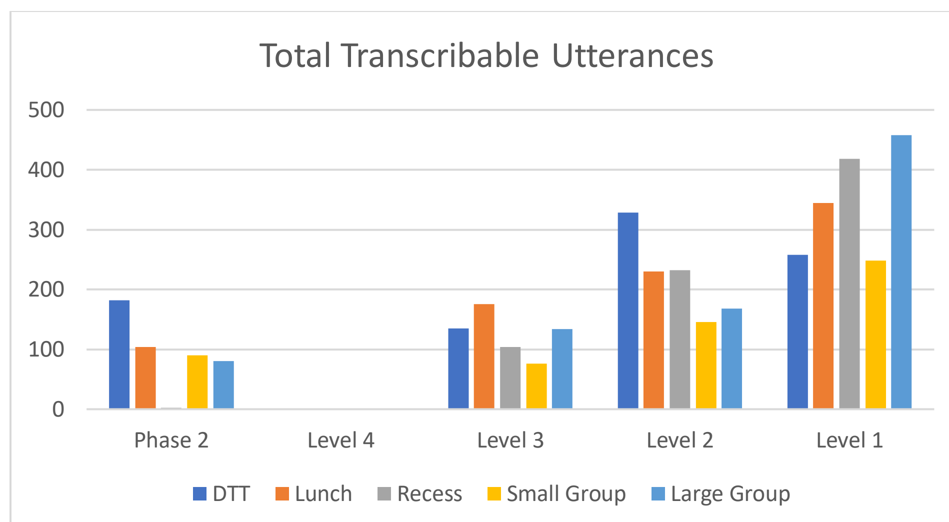

Figure 1: Total Transcribable Utterances

Non-Transcribable (NTV) Utterances. In total, single consonants were produced most frequently. Aypical (i.e., yell, grunt, scream, growl) utterances were the second most frequently produced utterance type. Laughter occurred third most frequently. Distress utterances came in fourth. Lastly, Non-English speech sounds (NES) were utilized least frequently, as not all participants produced non-English speech sounds. No participants produced utterances that were unable to be placed within the previous categories (i.e., "other").

Overall. No participants produced utterances that could not either be categorized as TV or NTV (i.e., "CBD"). Overall, the group produced slightly more TV than NTV utterances, with a TV: NTV ratio of 1.05.

Activity Types

Direct Instruction (DTT). DTT time consisted of the child working within the classroom one-on-one with a teacher. In DTT recordings, the teacher often targeted following complex one-step directives and making requests verbally. The prompt, "Say ___" was often used and preferred activities and snacks were used to reinforce the child's production of Phase 2 utterances. During DTT, more TV utterances were spoken than NTV, with a TV: NTV ratio of

1.47. Single consonants were produced most frequently during DTT, followed by Phase 2, Level 1, Phase 2, Level 3, Atypical, Laugh, Distress/NES. No vocalizations were categorized as "other."

Lunch. Lunch time took place each day within the classroom, with teachers seated eating their own lunch with the children. Total, during lunch time, more TV utterances were spoken than NTV, with a TV: NTV ratio of 1.65. Level 1 utterances were produced most frequently during DTT, followed by single consonants, Level 2, Atypical, Level 3, Phase 2, Laugh, NES, and lastly, Distress. No vocalizations were categorized as "other."

Recess. Recess time was spent outside, weather permitting, on the playground. The class went outside as a group and at times other classes were on the playground at the same time. When weather or other factors did not allow playground access, the class stayed within their classroom and had free play or snack time during Recess. In total, during recess, more NTV utterances were spoken than TV, with a TV: NTV ratio of 0.65. Single consonants were produced most frequently during this time, followed by Atypical, Level 1, Level 2, Level 3, Laugh, Distress and Phase 2 utterances. No NES utterances were spoken during recess time. No vocalizations were categorized as "other."

Small Group Activities. Interactive small group activities took place within the classroom with one or more classmates with a paraprofessional or teacher leading the activity. During small group time more TV utterances were spoken than NTV, with a TV: NTV ratio of 1.25. Level 1 utterances were produced most frequently during DTT, followed by single consonants, Level 2, Atypical, Level 2, Level 3, NES, Distress, and Laugh utterances. No NES were spoken. No vocalizations were categorized as "other."

Large Group Activities. Large group activities in which the entire class was included in interactive games and story telling took place within the classroom and were led by a teacher. During large group time more TV utterances were spoken than NTV, with a TV: NTV ratio of 1.50. Level 1 utterances were produced most frequently during DTT, followed by single consonants, Atypical, single consonants, Level 2, Level 1, Laugh, Distress, and NES utterances. No vocalizations were categorized as "other."

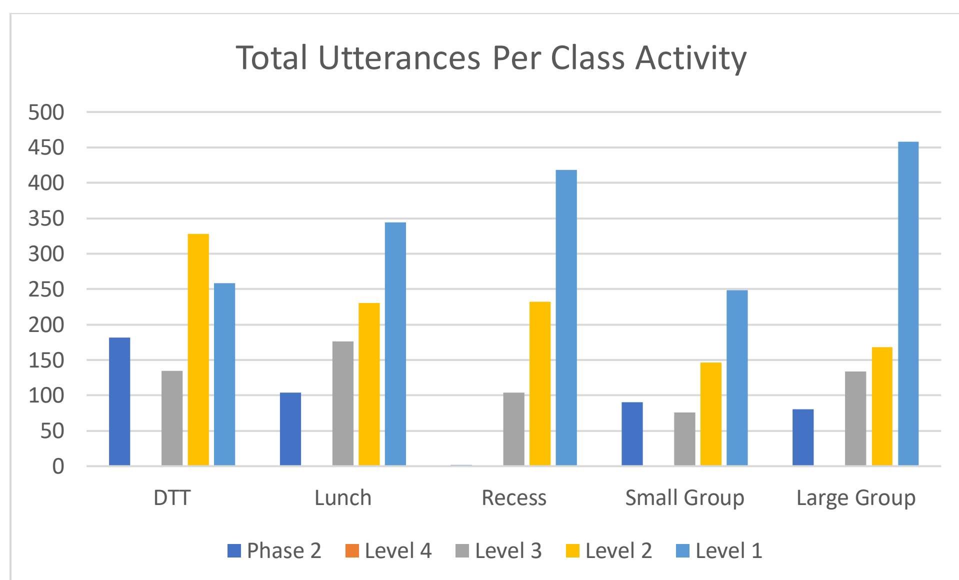

Figure 2: Total Utterances Per Class Activity

Participants

Aiden. Aiden's most frequent vocalization type across class times was single consonant, followed by Atypical, Level 2, Level 1, Level 3, Distress, NES, Laugh, and lastly, Phase 2 utterances. His overall ratio of TV: NTV utterances was 0.93. He produced Phase 2 utterances equally frequently across small group, large group, and lunch periods. Aiden produced his most complex preverbal language (i.e., Level 3) at lunch. He produced Levels 2 and 1 most frequently at recess. He produced his highest counts of all NTV subcategories in recess as well, with the

exception of NES, which he produced the most of during small group activities. He produced the most total NTV vocalizations during DTT.

Ana. Ana's most frequent vocalization type across class times was Level 1, followed by single consonant, Atypical, Laugh, Level 2, NES, Distress/Level 3 utterances. Her overall ratio of TV: NTV utterances was 0.93. She produced Phase 2 only during large group time. Ana produced her most complex preverbal language (i.e., Level 2 and 3) at lunch. She produced Level 1 utterances most frequently during large group time. She produced the most NTV utterances during recess. She produced Phase 2 utterances only during large group time.

Isabella. Isabella's most frequent vocalization type across class times was Atypical, followed by Phase 2, Level 2, single consonant, Level 1, Level 3, Laugh, and Distress utterances. She did not produce any NES. Her overall ratio of TV: NTV utterances was 1.21. Isabella produced Phase 2 vocalizations across all class times; however, most frequently during DTT. She produced her most complex preverbal language (i.e., Level 3) during large group time. She utilized Level 2 and 1 utterances most frequently during DTT. She produced her most NTV utterances during recess.

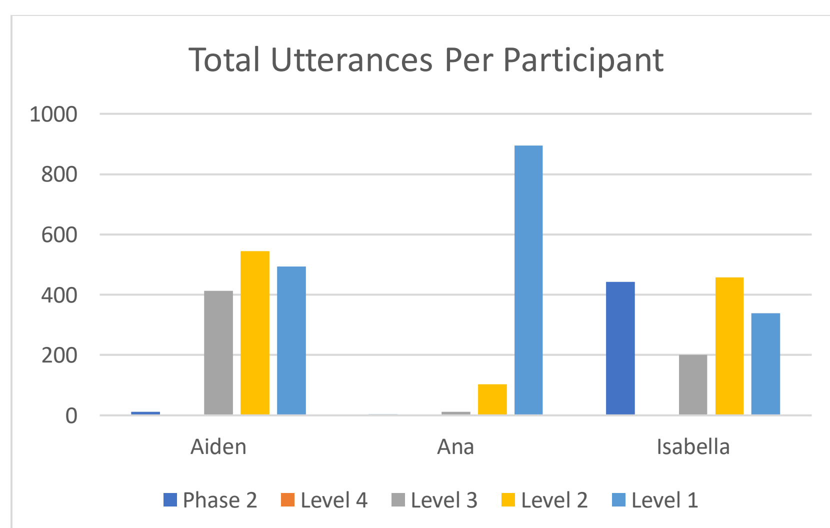

Figure 3: Total Utterances Per Participant

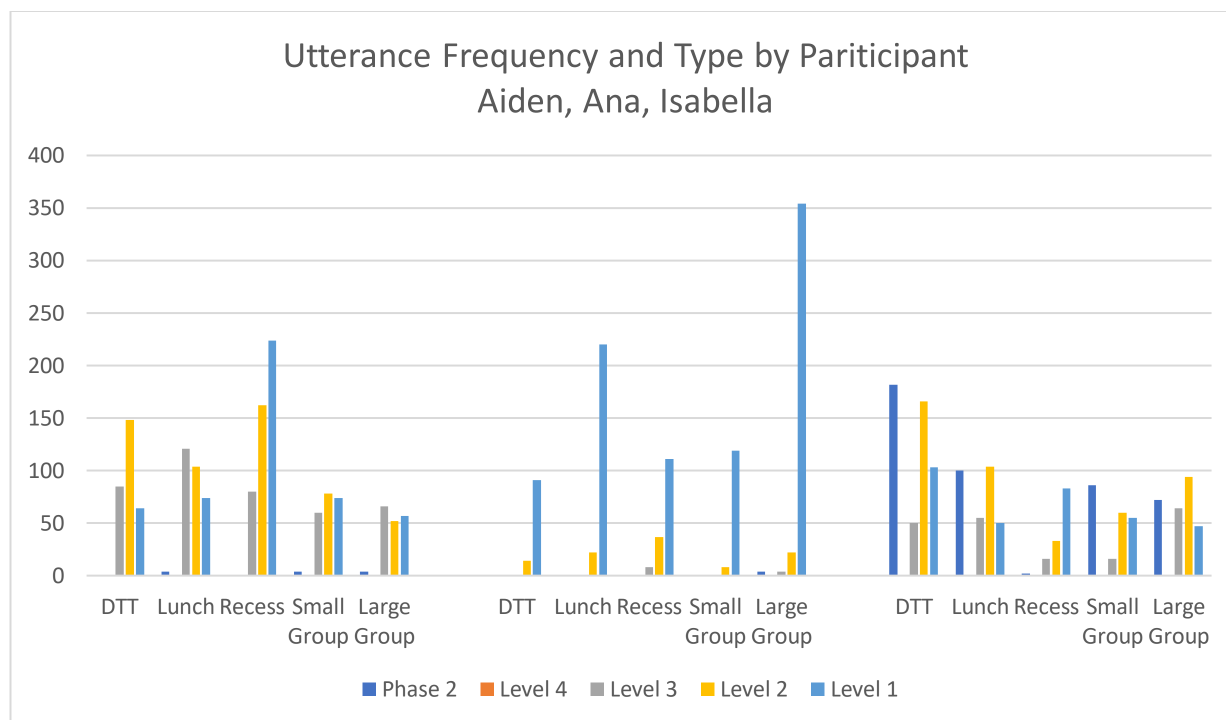

Figure 4: Utterance Frequency and Type By Participant

Summary

Frequency of utterance types. In total, Isabella and Ana produced more TV than NTV utterances. They had TV: NTV ratios of 1.24 and 1.21, respectively. Aiden, however, produced slightly more NTV utterances, with a TV: NTV ratio of 0.93. Excluding Level 4 utterances which did not occur in any segments recorded, Phase 2 utterances were the least common TV type across class activities for two out of three participants (Ana and Aiden). In contrast, Isabella produced Phase 2 utterances more frequently, with Phase 2 being her second and third-highest TV utterance types across all class activities. In fact, Isabella utilized Phase 2 utterances 189.43% and 196.41% more Phase 2 utterances total as compared to Aiden and Ana, respectively. However, Aiden produced Level 3 utterances 188.68% and 68.84% more than Ana and Isabella, respectively. The total frequency of Aiden and Isabella's Level 2 utterances were comparable, with Aiden producing just 17.38% more than Isabella; meanwhile, Ana produced

only 18.93-22.54% as many Level 2 utterances as the other participants. In addition, Ana produced more than twice as many (57.93% and 90.35% difference, respectively) Level 1 utterances than both her counterparts Isabella and Aiden. No one child or pair of children consistently produced similar language complexity levels in total.

Utterance types within class activities. Not only the frequency but also the timing of language complexity varied greatly between participants. Both Ana and Aiden spoke the most Phase 2 utterances during large group activities; Isabella, in contrast, spoke her highest amount of Phase 2 utterances during DTT. Each child produced Level 3 utterances most frequently during different class activities. Aiden had the highest total Level 3 count during Lunch time, while Ana spoke the most Level 3 utterances during recess; Isabella produced the most Level 3 utterances while engaged in Large Group activities. Each child also produced their highest total of Level 1 (i.e., single vowels or CV syllables containing /h/ or a glottal replacement) utterances during differing class activities. Aiden spoke the most Level 1 utterances during Recess, while Ana did in Large Group; Isabella produced this utterance type most frequently during DTT.

Aiden and Ana both produced Level 2 utterances most frequently during Recess. Isabella, rather, produced had the highest Level 2 count during DTT. Isabella and Ana spoke the most NTV utterances during recess periods; Aiden, rather, spoke the most NTV during DTT. In summary, no one child or pair of children consistently produced similar language complexity levels during selected class activities.

DISCUSSION

The literature involving minimally verbal children with ASD speaks to the highly varied language outputs of individual children (Rose, Trembath, Keen, & Paynter, 2016). This was similarly demonstrated in the current study. In this study, the child that produced higher levels of complex language in particular activities did not consistently produce similar levels of the complexity in other activities. Similarly, the child that vocalized the most frequently during a certain class activity did not produce more complex language than his/her peers that spoke less frequently. Consistent trends were not identified across participants, vocalization types, or class activities. This could be attributed to the language and/or interaction profiles of the participants, the amount of prompting in a given activity, and the general variability of language use across activities.

Similar to TV utterances, no definite relationships were observed in the three participants' productions of NTV vocalizations, either. Aiden and Isabella both produced Aypical (i.e., yell, grunt, scream, growl) NTV utterances most frequently during recess time, and Aiden and Ana each produced their most single consonants during recess. All three children produced the majority of their NTV utterances in differing class times. Aiden had the highest total Laugh count during recess time, while Ana laughed the most during DTT. Isabella, meanwhile, produced the most Laugh utterances while at lunch period. Aiden had the highest total Distress utterance count during recess, while Ana produced the most distress utterances during small group activities. Isabella produced the most Level 3 utterances while engaged in large group activities and DTT. Aiden had the highest total NES during small group activities,

while Ana spoke her most during lunch. In contrast, Isabella did not produce non-English speech sounds throughout all segments coded.

While the frequency of specific NTV utterances were not within the scope of this study, these additional data illustrate that even communication outside the transcribable spectrum varies greatly between minimally verbal children with ASD. Stimulability, interest in social interaction with peers, interaction with adults, preferred activities and reinforcers, and many other factors may effect the frequency and timing of a child's most complex preverbal communication. Within the bounds of this study's scope, these factors were unable to be incorporated and therefore no relationships could be confidently identified.

Limitations

It is worth noting the limitations associated with the methods of this study. Researchers did not investigate the participants' specific language abilities before beginning coding so as to limit coding bias; however, knowing more about the participants' specific language profiles would have likely prompted the researchers to narrow criteria used to define "minimally verbal" in this study.

This study did not differentiate between prompted and spontaneously initiated or imitative and generative utterances. For example, the teachers frequently used instructional procedures to encourage the production of Phase 2 utterances. During DTT, in particular, mand-model prompts such as "Say ___" or "Ask ___" were used to elicit a request or comment. This instructional approach was aimed at increasing MLU, facilitating meaningful requests, and/or increasing the production of functional language. Phase 2 utterances were reinforced by preferred activities or items (e.g., snacks or toys) to foster meaningful language. Further analysis

differentiating prompted or imitative utterances and spontaneously initiated generative utterances would provide insights on children's independent use of utterances.

It is also worth noting that while the classroom was highly structured, daily variants in class activities (e.g., running late, additional snack time, recess taking place indoors rather than outside, etc.) did arise. Therefore, some class time segments coded may have, in reality, been transition time, time utilized to make up work, or time used to provide a break for the class. Coders adhered to protocol by still using these recordings.

Lastly, inter-rater reliability was found to be a contributing limitation of this study. Despite high levels of agreement for the most frequently occurring utterances (Level 1), there were lower levels of agreement for the less frequently used utterances. This variance in percent agreement is likely related to difficulty in identifying which vocalizations were truly the target child's, rather than other classmates. At times, coders were required to make a judgment as to whether a vocalization was a very low-volume vocalization from the target child, or a particularly loud vocalization of a neighboring child. The variance in percent agreement is also likely related to the mutually exclusive status of the coding scheme. For instance, a child might produce /ga/, a Level 2 utterance, while also raising their voice at an unusually high pitch, such that the coder categorizes the utterance as Atypical. Similarly, some vocalizations might rarely fit into multiple categories. Several children frequently produced /hm/, a sound that some might categorize as a hum (Atypical), while others might categorize as a Phase 1 utterance containing a true consonant, /m/.

Conclusions and Future Directions

The current results further demonstrate the individual language profiles of children who are often categorized into a single group of minimally verbal. This leads to interesting clinical

and research implications about when to assess, selecting targets, and implementing instructional procedures. Future research examining differences between generative and imitative language in children at the early stages of language use would add to the knowledge base of how children who are minimally verbal use language. Additionally, examining activity types across specified language, interaction, and preferred activity profiles would more clearly describe potential similarities or differences.

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APPENDIX A: CODING MANUAL

Introduction

This is a project investigating how minimally verbal preschool-age children with autism vocalize within a self-contained classroom. These children each wore a LENA DLP recording device to capture their vocalizations throughout the school day. Coders will be given access to these audio clips; each clip will last no longer than 30 minutes each. Within each audio clip, coders will identify individual vocalizations made by the child wearing the DLP and then categorize each vocalization using Figure 4. Coders are encouraged to listen to recordings more than once if needed.

Coding Procedure

- Listen to audio file.
- Identify when a vocalization starts and ends by the child wearing the LENA DLP
    - An individual vocalization is separated from other vocalizations by one second of silence preceding and following the utterance OR when the utterance switches from one category to another.
- Once an individual vocalization has been identified, categorize it using the information below.
    - Phase 1: preverbal communication
        - Transcribable vocalizations (TV)
            - Level 1 : a vowel or CV syllable containing /h/ or a glottal replacement.

        - Level 2: single consonant or identical consonants.
        - Level 3: contains at least two consonants (consonant clusters or a pair of cognates do not count)
        - Level 4: contains a consonant cluster
    - Non-transcribable vocalizations (NTV)
        - Laugh: a sound presumed to indicate pleasure; a loud burst of sound or a series of quieter vocalizations.
        - Distress
            - A sound presumed to indicate negative emotion (e.g., cry/whine, scream)
        - Atypcial
            - (e.g., yell, grunt, squeal, growl)
        - Non-English speech sound
            - (e.g., lip smack, tongue click, trills)
        - Single Consonant
        - Other
    - (CBD) Could not be determined (neither TV nor NTV)
    - NOTE: Refer to Figure 4 for more information on TV, NTV, and CBD criteria.
  - Phase 2: words (non-imitated, spontaneous, intentional)
- Tally the vocalization using Figure 5 below.
- Repeat. Continue until all vocalizations in the clip are categorized and tallied.

(criterion adapted from Plumb & Wetherby, 2013 and Tager-Flusberg et al, 2009)

Vocalization variable	Definition
Transcribable vocalization (TV)	A syllabic vocalization that contains at least a vowel and may also contain a consonant
Level I	Contains a vowel (e.g., /i/) or a CV containing /h/ or a glottal replacement
Level II	Contains a true, well-formed single consonant or identical consonants
Level III	Contains two or more different consonants, not including consonant clusters or differing solely in voicing
Level IV	Contains a well-formed consonant cluster
Nontranscribable vocalization (NTV)	A vocalization that does not contain a recognizable consonant or vowel or contains a vowel with atypical phonation
Laugh	An audible, vocal expulsion of air from the lungs that can range from a loud burst of sound to a series of quiet chuckles and is usually associated with pleasure
Distress	A vocalization associated with a negative emotional state, including a *cry/whine* (high-pitched, plaintive vocalization) or a *scream* (loud, long, intense cry)
Atypical	A vocalization that demonstrates atypical phonation, including a *yell* (loud, nondistress vocalizations), a *grunt* (short vocalization produced with low pitch and increased force), a *squeal* (vocalization that at some point enters into maximally high pitch or falsetto), and a *growl* (low-pitch, often creaky-voice vocalization; Sheinkopf, Mundy, Oller, & Steffens, 2000)
Non-English	A vocalization that is not considered consonantal in English and does not contain a vowel sound, including a *lip smack*, a *tongue click*, a *raspberry*, an *alveolar trill*, and a *uvular trill*
Single consonant	A consonant produced with no accompanying vowel, such as a sustained /s/ or an /m/ produced in isolation
Other	An NTV that is not captured in the previous NTV categories
Could not be determined (CBD)	A vocalization in which it is not clear whether it is a TV or an NTV (e.g., there is not a clear auditory signal)

Figure 5: Plumb & Weatherby, 2013

Audio Clip Name: Coder name:

Child name: Child DOB:

	Phase 1						Phase 2
	TV				NTV	CBD	
	Level 1	Level 2	Level 3	Level 4			
Time ↓							
	Total	Total	Total	Total	Total	Total	Total Phase 2 Vocalizations:
	Total TV vocalizations:						
	Total Phase 1 vocalizations:						

Figure 5: Segment Coding

APPENDIX B: RECORDING SCHEDULE

Aiden, Day 1

LENA recording 7:15am-2:30pm									
Direct instruction 10:15-11:15am		Outside time 9:10-9:40am		Small group 9:50-10:05am		Lunch 11:15-11:35am		Large group 11:35am-12:10pm	
5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV Count

Day 2

LENA recording 7:15am-2:30pm									
Direct instruction 10:15-11:15am		Outside time 9:10-9:40am		Small group 9:50-10:05am		Lunch 11:15-11:35am		Large group 11:35am-12:10pm	
5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV Count

Day 3

LENA recording 7:15am-2:30pm									
Direct instruction 10:15-11:15am		Outside time 9:10-9:40am		Small group 9:50-10:05am		Lunch 11:15-11:35am		Large group 11:35am-12:10pm	
5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV Count

Ana, Day 1

LENA recording 7:15am-2:30pm									
Direct instruction 10:15-11:15am		Outside time 9:10-9:40am		Small group 9:50-10:05am		Lunch 11:15-11:35am		Large group 11:35am-12:10pm	
5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV Count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV Count

Day 2

LENA recording 7:15am-2:30pm									
Direct instruction 10:15-11:15am		Outside time 9:10-9:40am		Small group 9:50-10:05am		Lunch 11:15-11:35am		Large group 11:35am-12:10pm	
5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV Count

Day 3

LENA recording 7:15am-2:30pm									
Direct instruction 10:15-11:15am		Outside time 9:10-9:40am		Small group 9:50-10:05am		Lunch 11:15-11:35am		Large group 11:35am-12:10pm	
5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV Count

Isabella, Day 1

LENA recording 7:15am-2:30pm									
Direct instruction 10:15-11:15am		Outside time 9:10-9:40am		Small group 9:50-10:05am		Lunch 11:15-11:35am		Large group 11:35am-12:10pm	
5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV Count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV Count

Day 2

LENA recording 7:15am-2:30pm									
Direct instruction 10:15-11:15am		Outside time 9:10-9:40am		Small group 9:50-10:05am		Lunch 11:15-11:35am		Large group 11:35am-12:10pm	
5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV Count

Day 3

LENA recording 7:15am-2:30pm									
Direct instruction 10:15-11:15am		Outside time 9:10-9:40am		Small group 9:50-10:05am		Lunch 11:15-11:35am		Large group 11:35am-12:10pm	
5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV count	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV	5 min segment w/ highest CV count	5 min segment w/ 2nd highest CV Count