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Using the Language Environment Analysis (LENA) system in preschool classrooms with children with autism spectrum disorders

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Abstract

This study describes the language environment of preschool programs serving children with autism spectrum disorders (ASDs) and examines relationships between child characteristics and an automated measure of adult and child language in the classroom. The Language Environment Analysis (LENA) system was used with 40 children with ASD to collect data on adult and child language. Standardized assessments were administered to obtain language, cognitive, and autism

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severity scores for participants. With a mean of over 5 hours of recording across two days several months apart, there was a mean of 3.6 child vocalizations per minute, 1.0 conversational turns (in which either the adult or child respond to the other within 5 seconds) per minute, and 29.2 adult words per minute. Two of the three LENA variables were significantly correlated with language age-equivalents. Cognitive age-equivalents were also significantly correlated with two LENA variables. Autism Diagnostic Observation Schedule severity scores and LENA variables were not significantly correlated. Implications for using the LENA system with children with ASD in the school environment are discussed.

Keywords
autism spectrum disorders, preschool, language, natural environment, LENA system

Introduction

With an estimated one out of 110 children meeting diagnostic criteria for autism spectrum disorders (ASD) in the United States (Centers for Disease Control and Prevention, 2009), schools are serving an ever increasing number of these children. Disordered language development is a hallmark of ASD that typically necessitates early intervention, given that positive outcomes in this developmental domain are consistently linked to improvements in communication and social skills, adaptive behavior, autism symptomatology, and level of independence (Howlin et al., 2004; Szatmari et al., 2003). The purpose of the current study is to measure the language and language environment of children with ASD in the classroom using the Language Environment Analysis (LENA) system, an automated system with the capacity to efficiently capture extensive amounts of data.

Traditionally, researchers and clinicians have assessed children's communication and language skills with a variety of measures, including parent report, standardized tests, structured and semi-structured observations (Bornstein and Haynes, 1998; Pasco et al., 2008) to determine the efficacy of interventions addressing deficits in language development. Although such measures offer valuable child-specific language information to guide and monitor the success of language interventions for children with ASD, experts in the field of ASD have debated the appropriateness and effectiveness of different methods for assessing the language skills of these children (Charman et al., 2003; Condouris et al., 2003; Koegel et al., 1997; Luyster et al., 2008), given that children with ASD tend to 'over-perform' in more structured or contrived testing situations (e.g., Condouris et al., 2003). Researchers and practitioners have struggled to effectively assess language in the natural environment, confronting issues such as the time-consuming nature of data collection (Hart and Risley, 1995).

In addition, current assessment methods do not adequately capture adult-child interactions, which are thought to have a critical role in the development of language in young children (Hart and Risley, 1995). One environmental characteristic influencing children's language development is parent and teacher input (Siller and Sigman, 2002; Yoder and Warren, 1998). In a seminal study, Hart and Risley (1992) found that the amount of language input at home (words per day) collected longitudinally from 10 to 36 months of age predicted the cognitive scores of children at 3 years. The amount of teacher input also has a pivotal role, with an established link between teachers' mean length of utterance and preschoolers' language growth over the course of a school year (Cross, 1989). Thus, adult-child interactions appear to influence child language development.

In turn, child characteristics such as disability status also have been shown to influence interactions with adults. Alarmingly, research shows that adult-child interactions with children with developmental disabilities occur less frequently than with typically developing peers (Girolametto

et al., 2000), and teachers may be less responsive towards children with disabilities (Pecyna Rhyner et al., 1990; Rimm-Kauffman et al., 2003). Given the heterogeneity of ASD, it is possible that specific child characteristics (e.g., cognitive and language abilities, autism severity) within this population of children may have an impact on their interactions with teachers.

Unfortunately, little is known about how the language of children with ASD is influenced by these transactional effects in the school setting. Instruments that efficiently measure the language ability of children with ASD in the natural environment are needed. Although research highlights the importance of the preschool language environment for children with and without disabilities (Girolametto and Weitzman, 2002; Mahoney and Wheeden, 1999), there is a paucity of information on the language environment of preschool programs serving children with ASD. This could be due, in part, to a lack of an efficient measurement tool that can capture and analyse relevant aspects of the natural language environment. A recently developed audio recording technology, the Language Environment Analysis (LENA) system, may be a useful tool to characterize the natural language environment of classrooms serving children with ASD.

The LENA system consists of a digital language processor (DLP) and speech recognition software. It was developed to monitor the language and audio environment of children between 2 and 48 months of age, and therefore can be used with children who exhibit a wide range of language skills, such as those with ASD. The DLP records up to 16 hours of the natural audio environment, and the software then processes the auditory data and provides information on three primary child and adult variables. Adult word counts (AWCs) refer to words spoken to or near the child by an adult, and excludes overlapping adult and child speech, TV, and radio. Child vocalizations (CV) are speech-related sounds, including words, babbling, and single sounds and excluding crying, whining, and vegetative sounds (e.g., breathing, burping). Finally, child turns (CT) are adult-child alternations when either the adult or child respond to the other within 5 seconds. The software also classifies information about the audio environment, including television and electronic sounds, noise, and silence. The system differentiates between meaningful (35 decibels hearing level [dB HL] or greater) and distant (less than 35 dB HL) speech (Yoshinaga-Itano and Gilkerson, 2010). As reference points, a whisper is approximately 20 dB HL and typical conversation is around 60 dB HL.

Recently, LENA was used to study the language environments and language development of children with ASD primarily in the home setting (Warren et al., 2010). Each of the 26 participating families provided 8 days of LENA recordings (16 continuous hours each day) from their children with ASD. For analyses, the AWC, CV and CT data from the ASD group were compared with a subset of 78 typically developing children from the Natural Language Study, the original study conducted to gather normative data on the LENA (Gilkerson and Richards, 2008). The two groups were matched on key demographic variables, such as child gender and maternal education. Comparisons of the two groups suggested that children in both groups had relatively comparable language environments as measured by AWCs. In contrast, the child language characteristics of the two groups differed significantly, with the ASD group averaging 131 fewer conversational turns and 625 fewer vocalizations per day than typically developing children. They also found that higher AWCs and CTs were significantly correlated with less severe autism symptoms and higher language ability.

This descriptive study provides a natural extension of the Warren et al. (2010) study by characterizing the language environment of children with ASD in a preschool setting, and represents one of the first efforts to use the LENA system in a classroom setting. It also fills a gap in the literature by examining both child characteristics and aspects of the language environment in school programs serving children with ASD. Our research goals were to (1) characterize the preschool language environment in terms of AWCs, CVs, and CTs as measured by the LENA system, (2) examine differences in LENA measures between the beginning and end of a school year, and (3)

Table 1. Descriptive statistics for age and assessments.

	LENA	PLS-4		Mullen		ADOS
	Chronological age (months)	Total SS[a]	Total age equivalent (months)	Total SS[a]	VR[b] – age equivalent (months)	Severity score
Mean	48.3	62.9	25.6	60.7[c]	32.1	7.6
SD	6.9	14.7	11.3	16.3	14.4	1.6
Range	36–61	50–97	6–50	49–108	6–69	4–10

[a]SS: Standard Score.
[b]VR: Visual Reception subscale of Mullen.
[c]Complete Mullen data were missing for one participant.

investigate associations between standardized measures of language, cognition, and autism severity and the LENA language-related variables.

Methods

Participants

Forty children who were part of a larger study examining preschool programs for young children with ASD were included in this study. All participating children were from self-contained classrooms that served only children with disabilities in a Southeastern school district in the United States. There were 32 males and 8 females, which reflects the gender ratio typically seen in ASD. Of the 40 participants, 72.5% (n=29) of the participants' parents identified their children's race as White, 17.5% (n=7) as Black, and 10% (n=4) as Asian. Based on US Census guidelines, parents also were asked to identify their child's ethnicity (whether or not they were Hispanic) in addition to identifying the child's racial group status. Fifteen percent (n=6) of the participants' parents identified their children's ethnicity as Hispanic. Children were ages 3–5 (mean age=3.95). All children in the study had a prior educational or community diagnosis of either ASD or developmental delay as reported by the parent, and met diagnostic criteria for ASD on the most recent Autism Diagnostic Observation Schedule (ADOS) algorithms (Gotham et al., 2009). The participants had varying levels of autism severity and a range of verbal and cognitive abilities (Table 1).

A total of 15 classrooms were included in the study. Some of the self-contained classrooms had a strong adherence to particular theoretical and conceptual frameworks (e.g., TEACCH), while other classrooms were more eclectic. The researchers used rigorous inclusion/exclusion criteria to ensure that classrooms were high quality environments. For example, teachers had to be licensed special educators with at least 2 years of experience teaching preschoolers with ASD prior to the start of the project. Further, classrooms were screened to ensure instructional quality by using a psychometrically validated tool (Professional Development in Autism Program Assessment; Professional Development in Autism Center, 2008) to determine overall quality of the classroom environment. Based on this measure, the classrooms in the study used evidence-based practices for children with autism, including individualized support, visual cues and schedules, clearly marked activity areas, specialized curriculum, and functional behavior assessment.

All classroom teachers were female and white. One of the 15 teachers identified herself as Hispanic. All teachers were certified to teach in preschool classrooms. Six of the teachers had bachelor's degrees, eight teachers had master's degrees and one teacher had an education level above a master's degree. Teaching experience ranged from 4 to 28 years with a mean of 10.8 years.

Measures

The Preschool Language Scale (PLS-4; Zimmerman et al., 2002) is a valid (Zimmerman and Castilleja, 2005) and reliable measure used to assess communication behaviors (e.g., gestures, eye contact) and determine language delays for children from birth through 6 years, 11 months. The PLS-4 provides auditory comprehension and expressive communication subscale scores as well as a total language score. For the current study, the age-equivalent scores based on the total language score of the PLS-4 were used to estimate communication abilities.

The Mullen Scales of Early Learning (Mullen, 1995) is a standardized, comprehensive assessment that measures gross motor (e.g., running), fine motor (e.g., stringing beads), visual reception (e.g., sorting) and language (receptive and expressive) abilities of children from birth through 68 months. The Mullen has an internal reliability of 0.91 (Mullen, 1995), and the validity of the measure for children with ASD has been established (Akshoomoff, 2006). For the purposes of this study, the age-equivalents from the visual reception (VR) subscale were used to estimate nonverbal cognitive ability. Age equivalents on the VR subscale was highly correlated with the overall Mullen score ($r=.77$, $p < .001$). We used the age-equivalent scores for the PLS-4 and Mullen because of floor effects associated with the standard scores.

The ADOS (Lord et al., 1999) is a semi-structured assessment considered to be the gold standard diagnostic instrument for ASDs with four different modules depending on the age and language abilities of the individual with ASD. A research-certified ADOS assessor administered the majority of the ADOS assessments (72.5%), with the remaining being administered by assessors who had been trained to a reliability criterion. The ADOS offers two domain scores: social affect, and restrictive and repetitive behavior, and a total score. For this study, researchers used a recently developed algorithm that can be calculated across modules to obtain overall severity scores (Gotham et al., 2009). Because participants received varied modules (either Modules 1 or 2), the severity scores offered the only method for comparing ADOS scores across all participants. The severity scores use a 10-point scoring metric ranging from 1 (no diagnosis of autism) to 10 (severe symptoms of autism).

LENA yields three language-related variables: AWC, CV, and CT. LENA also provides the proportion of meaningful data, referring to vocalizations and speech-related sounds captured during the recording. Silence, noise (e.g., overlapping speech, crying) and other audio environmental sounds (e.g., television) comprise the remainder of the recording (non-meaningful data). The reliability and validity of LENA has been extensively tested in typically developing infants and young children in the home environment (Xu et al., 2009). When compared with transcribers' word counts, LENA's AWC estimates from a 12-hour recording averaged 98% accuracy. A recent study examined the reliability of the LENA for use in preschool classroom settings (McCauley et al., 2011). Five-minute segments from 30 recording sessions in preschool classrooms for young children with and without ASD were coded by a human observer and compared with LENA counts. Total correlation between the human and LENA estimates was .81 ($p < .01$) across the adult, child, and other variable categories. Inter-rater reliability was calculated on 12% of the recordings and kappa was reported at .90. This suggests the LENA is a reliable tool for measuring the natural language of adults as well as children with ASD in a preschool classroom environment.

Procedures

The researchers inserted the LENA DLP into the pocket of a specially constructed vest, which was worn by the child participants at the beginning of the school day during typical classroom

Table 2. Raw[a] LENA data at Times 1 and 2.

	Time 1		Time 2	
	Range	Mean (SD)	Range	Mean (SD)
AWC	1771–10,898	4886 (1922)	2540–8385	4709 (1569)
CV	94–1231	492 (244)	233–1698	692 (305)
CT	22–440	163 (92)	60–424	189 (85)

[a]Raw data refers to frequency counts of the given behavior.

routines, such as breakfast, classroom activity areas (e.g, dramatic play, block center, manipulatives), and circle time. Research staff remained with children to assist with habituation to the vest as needed. Children wore the vest for approximately 3 hours, and teachers were instructed to continue their regular classroom routines. No other special directions were provided to the teachers or children. Children were not administered any standardized tests on the day during which they wore the LENA DLP to avoid artificial inflation of the LENA data. Data were collected on two school days approximately 6 months apart (near the beginning of the school year after following recruitment and near the end of the school year) for 37 of the 40 participants. The families of three participants withdrew from the study before the collection of Time 2 data.

The LENA recordings were transferred to a desktop computer equipped with the LENA software system, which uses programmed algorithms to calculate output data. LENA data were then exported to a Microsoft Excel spreadsheet. Owing to the discrepancies in total recording time for participants, the raw data were converted to rates. Total counts for each language-related variable (AWC, CV, and CT) were divided by the total amount of time in seconds for which LENA data were collected, and then multiplied by 60 to convert to occurrences per minute. To describe the language environment of the preschool classrooms, LENA data were examined separately at each time point, as well as compiled to estimate average rates of AWC, CV, and CT. We used correlations to examine the relationships between LENA rates and the language, cognition, and autism severity measures. Only Time 1 LENA data were used for the correlations to examine the concurrent association between the baseline standardized measures (Mullen, PLS-4, ADOS) and the LENA variables.

Results

Descriptive data for LENA

The mean amount of time that children wore the LENA device across the two sessions was 5 h 18 min (range: 2 h 11 min to 6 h 44 min). The proportion of meaningful data (vocalization and speech-related sounds within an approximate 1.8 meter radius of the DLP) averaged 26.2% (range: 14.6% to 41.3%). The raw LENA data for AWC, CV, and CT had much variance (Table 2). From the rate data, at Time 1 and Time 2 child participants averaged 3.1 and 4.1 vocalizations per minute (CV rate), respectively. There was a mean of 1.0 adult-child conversational turns per minute at Time 1 and 1.1 turns per minute at Time 2 (CT rate). The adults had a mean of 30.6 words per minute at Time 1 and 27.6 words per minute at Time 2 (AWC rate). See Table 3 for descriptive data on rates of each of the LENA measures at both time points, as well as a mean across time points.

Table 3. Descriptive statistics for LENA rate data.

	AWC rate (per min)			CV rate (per min)			CT rate (per min)		
	T1	T2	Mean	T1	T2	Mean	T1	T2	Mean
Mean[a]	30.6	27.6	29.2	3.1	4.1	3.6	1.0	1.1	1.0
SD	11.1	8.6	8.6	1.5	1.7	1.3	0.50	0.46	0.44
Range	10.9–58.6	12.6–45.7	12.1–47.3	0.59–6.4	1.4–8.8	1.2–5.8	0.12–2.4	0.30–2.3	0.10–1.9

[a]Total count data was divided by total duration data to compute mean for each LENA measure for the 37 participants who had data at T1 and T2.

Table 4. Correlations for LENA rate data and assessments.

	1 AWC-rate[a]	2 CV-rate[a]	3 CT-rate[a]	4 PLS-4[b]	5 Mullen-VR[b]	6 ADOS[c]
1	–	.27 (p=.095)	**.33** (p=.048)	**.35** (p=.026)	**.41** (p=.009)	–.06 (p=.710)
2		–	**.37** (p=.024)	**.33** (p=.040)	.16 (p=.332)	–.034 (p=.834)
3			–	.314 (p=.058)	**.33** (p=.048)	–.075 (p=.658)
4				–	**.87** (p < .001)	**–.51** (p=.001)
5					–	**–.51** (p=.0021)
6						–

[a]Rates per minute were used for the LENA measures.
[b]Age equivalent in months were used for PLS-4 and Mullen-Visual Reception.
[c]Severity scores were used for the ADOS.
Bold indicates significant values.

Comparison of Time 1 and Time 2 LENA data

To examine changes in LENA data, paired samples t-tests comparing Time 1 with Time 2 data for CV, CT, and AWC rates were conducted. There was a significant increase in CV rates from the beginning to the end of the school year (t=3.38, p=.002). Differences between Time 1 and Time 2 for CT rates (t=1.17, p=.250) and AWC rates (t=1.88, p=.069) were not statistically significant.

Correlations between LENA and standardized assessments

There were significant correlations (r) between the LENA variables, and significant correlations between the LENA variables and other developmental measures (see Table 4). Using a cut-off of p=.05, two of the three LENA variables were significantly correlated with each other: AWC and CT rates (r=.33), and CV and CT rates (r=.37). The AWC rates were significantly correlated with age-equivalents on both the Mullen-VR (r=.41) and total language PLS-4 (r=.35). The rate of CV and PLS-4 age-equivalent showed significant positive correlations (r=.33), as did the rate of CT and age equivalents on the Mullen-VR (r=.33).

One other correlation appears moderately correlated but was not significant: CT rate and PLS-4 age-equivalent (r=.31, p=.058). The ADOS severity scores were not significantly correlated with the three LENA language-related measures.

Discussion

This descriptive study used a combination of traditional measures and a new technology, the LENA system, to explore the preschool language environment of children with ASD and relationships between the environment and child-specific characteristics. Descriptive analyses of LENA data provided insight regarding adult input, child vocalizations, and adult-child interactions occurring in preschool settings serving children with ASD. In addition, correlational analyses revealed relationships between standardized measures of cognition and language scores, and adult and child language in a natural context, providing potential support for transactional theories of development. Results from this exploratory study offer a launching point for researchers to continue investigating the nature of the language environment in preschool programs and the influence of child characteristics and adult input on language development in children with ASD.

Describing the language environment of preschools

Overall, the raw LENA data indicate that there were a wide range of vocalizations (CV) produced by children, CTs between children and adults, and AWCs spoken to children. The algorithms used to analyze the acoustic data (cut off at 35 dB HL) allow an estimated 1.2 to 1.8 meter radius audio range for capturing the data (Warren et al., 2010; Yoshinaga-Itano and Gilkerson, 2010). Across both time points, the children in this study demonstrated per hour a mean of 216 vocalizations and 60 turns and were exposed to over 1,700 adult words. In comparison, data converted from Warren et al.'s study (2010) indicated that, in the home environment, children with ASD had 134 vocalizations and 35 turns per hour and were exposed to approximately 1,100 adult words per hour. From our limited data, it appears that the language environment of high quality autism preschool programs may differ from home environments. Presumably, this is a reflection of the larger number of people with whom a child can interact in the school setting or focused interventions occurring at school. Indeed, Warren et al. (2010) found that there were significant increases in all three LENA language measures during therapy sessions when compared with non-therapy time for 14 participants who had worn the LENA vest during therapy sessions. A collection of more hours of data in classrooms is needed to accurately compare differences in these environments and to develop a more complete picture of language environments for children with ASD in preschool settings.

Children showed significant increases in rates of vocalizations between Time 1 and Time 2, with a mean increase of approximately 60 vocalizations per hour. Of the 37 children with LENA data at both time points, 27 children had increases in CVs and 21 children had increases in CTs. Thus, the LENA system may be an appropriate tool to capture change in child language over a relatively short period of time. The increases in child vocalizations probably occurred from a combination of developmental gains and intervention efforts in the preschools. In addition, transactional theories suggest that language development in children is bidirectional, with both child and adult characteristics and behaviors affecting the course of development (Yoder and McDuffie, 2006). These increases in child output across the school year therefore probably lead to improved opportunities for learning, assuming that it is at least partially representative of an increase in interaction with adults and/or peers.

Our study of children with ASD in the preschool setting produced over 200 hours of recordings, with a mean of 26.2% of the recorded data classified as 'meaningful data'. Thus, about 50 hours of data regarding the natural language environment of preschools serving children with ASD were captured and analyzed with relative ease; in contrast, the Hart and Risley study (1995) of the home language environment required 6 years of transcription and analysis to analyze over 1000 hours of data. The proportion of meaningful data captured in the current study was comparable to previous studies in the home environment, which had a mean of approximately 20% meaningful data for children between 36 and 48 months of age (Kim Coulter, 2010, personal communication). Overall, these results support the utility of LENA in the classroom to study the language environment of children with ASD and present a promising avenue for monitoring and intervening in the language environment.

LENA data and other developmental measures

Both standardized language and cognitive measures showed positive correlations with some of the LENA measures. These positive correlations may reflect teachers' sensitivity to child differences and the impact of child characteristics on interactions in the school environment. First, it is possible that adults are skillfully adapting their language relative to the language and cognitive level of the students. That is, the students with lower language and cognitive abilities are hearing lower counts of adult words because the teachers are using shorter phrases or sentences. In addition, it could be that children with lower language or cognitive levels are eliciting less input from the adults in their environment compared with more verbal peers.

The age-equivalents for the PLS-4 showed significant positive correlations with rates for AWC and CV, and approached significance with CT rates. Similarly, Gilkerson and Richards (2009) reported that AWC, CT, and CV count data correlated significantly with total and subtest scores of standard receptive and expressive language measures such as the PLS-4 with similar magnitudes, .35, .36, and .38, respectively. The positive correlations between the LENA child data and the PLS-4 confirmed that both measures are capturing some overlapping information. Based on the level of correlations (r=.33 for CV and r=.31 for CT), it is clear that the LENA system is also capturing different information, with slightly less than 10% of the variance shared across the measures. These results suggest the data analyzed by LENA software contributes valid, yet unique information on the language use of children with ASD. Because the LENA is a natural language sample, it was anticipated that the tool would capture variables not already reported in standardized measure. At present, there is no other established tool for capturing these samples in a timely and cost-efficient manner (e.g., that does not require lengthy observations and transcriptions).

The correlation between ADOS severity scores and all LENA measures were non-significant and surprisingly low. In fact, the data suggested almost no relationship between the severity of autism symptoms and children's language in the classroom. The lack of significance could be a reflection of the small sample size or the limited variability in ADOS severity scores. Because the ADOS severity scores are designed to be applied across ADOS modules, which are chosen based on the child's level and flexibility in language use (Gotham et al., 2009), it is also possible that the severity scores have excluded some of the variability in language level. In addition, the ADOS scores capture a great deal of nonverbal information (e.g., gestures, eye contact) and information unrelated to communication (e.g., repetitive behaviors), so it is less surprising that the LENA measures and ADOS are not capturing much overlapping information.

Clinical and educational implications

Although the research on LENA and children with ASD is still in its infancy, the procedures and results of this pilot study provide early support for the use of LENA in school settings. Given the efficiency of LENA to capture large amount of data in the natural environment with minimal effort by clinicians or teachers, this tool offers an exciting complementary and alternative method for observing progress in child communication. Also, the tool could be used by teachers and clinicians to monitor their own performance in the classroom. It could be especially helpful in examining language environments during different activities across a child's day. Finally, this tool offers new possibilities to more closely examine the transactional impact of language across a school year or over the course of an intervention.

Challenges and considerations in using LENA

Although LENA has the potential to inform researchers and clinicians about children's language development and environments, use of the LENA DLP in the classroom context and interpretation of LENA data with children with ASD requires the following considerations. If the LENA system is extended to use in classroom environments, the DLP cannot be worn for the recommended 12 hours per day and may pick up more background noise, which could result in decreased accuracy of data. Based on extensive development and testing, it is estimated that the LENA system does not capture speech outside of an approximate 1.8 meter radius from the child (Warren et al., 2010). Conceivably, significant quantities of speech in a classroom may be directed at a child or group of children by a teacher who is more than 1.8 meters away, resulting in less useable data. However, the proportions of meaningful data captured in the current study and previous studies in the home environment were similar (Kim Coulter, 2010, personal communication), so it appears that the school environment does not diminish the amount of useful data that can be collected.

Some characteristics common in children with ASD may affect the LENA data. For example, children with ASD may have artificially high vocalization counts due to echolalia as found by Warren et al. (2010) in his study using LENA in children's homes. Although echolalia can inflate the CV count, echolalia can be an important developmental step for children with ASD, such that the inflated scores may actually reflect skill progression. Also, the output from the LENA Pro software does not provide information about the intentionality of vocalizations or speech, nor does it capture nonverbal gestures of adults, peers, or the target child. Finally, because LENA only captures both verbal and vocal input from children, it is probably not the most appropriate tool in capturing the communicative skills for students who do not yet vocalize. Research suggests that lack of communicative intent and difficulty with nonverbal means of communication should be targets of intervention in addition to expressive language (Kasari et al., 2005). Thus, the use of a more traditional observational system, including videotaping and coding of discrete communicative behaviors, is probably the most accurate method in capturing the non-vocal communication skills of non-vocal individuals with ASD.

Study limitations

Given that the study is in its initial phase, we have access to only a small sample size of 40 children with ASD and there is no comparison group of typically developing children. Furthermore, audio data were only collected on 1–2 days for a limited amount of time per child. Owing to the small sample size and minimal recording time, we cannot make firm conclusions about the specific

LENA language-related variables of AWC, CT, and CV. In addition, the LENA vest was easily visible to the adults in the classrooms, so adults may have directed more language towards the child wearing the LENA vest, creating a Hawthorne effect. However, it is unlikely that the teachers would have been able to shift focus away from the other children in the classroom because the study occurred in classrooms serving only children with disabilities. Despite these limitations, some LENA measures were significantly and moderately correlated with age-equivalent scores from standardized assessments of language and nonverbal cognition.

Future directions

The LENA system offers a reliable and efficient method for collecting data related to language development and the language environment. This exploratory study offers a starting point for describing the language environment of preschool classrooms serving children with ASD and determining how these measures could be used to assist researchers and practitioners to provide optimal school-based interventions. In efforts to establish a research base, it will be valuable to collect normative data for both typically developing children and children with ASD using the LENA system in the school setting and establish guidelines to promote standard and optimal methods (e.g., length of data collection) in this new setting. Intensively examining the nature of the language environment and language development across different classroom situations and settings may help to inform and support implementation of maximally beneficial intervention techniques for children with ASD who exhibit severe language and communication delays. For example, research on children with other disabilities in early childhood settings suggests that child language and adult language vary with context (Girolametto et al., 2000). Thus, it may be useful to look at LENA data in relation to specific contexts across the day. Using the LENA system for research in classrooms will contribute to a deeper knowledge of the language environment of preschoolers with ASD. There is ample evidence that a high quality preschool classroom is linked to a number of important child outcomes (e.g., language ability; Burchinal et al., 2008; Mashburn et al., 2008). Although it is generally accepted that a high quality learning environment is beneficial for both children with and without disabilities (Hestenes et al., 2008), the impact of a high quality classroom on children with ASD has not caught the attention of researchers. Combining LENA data from various contexts across the day with research on the importance of a high-quality preschool language environment will allow researchers, practitioners and other stakeholders to advance professional development efforts and optimize interventions for students with ASD.

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