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## Research in Autism Spectrum Disorders

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# Child and classroom characteristics associated with the adult language provided to preschoolers with autism spectrum disorder

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## ABSTRACT

The aim of this study was to examine associations between the automated Language ENvironment Analysis (LENA) system adult word count (AWC) variable and characteristics of classrooms (e.g., teacher burnout) and preschoolers with autism spectrum disorder (ASD) (e.g., autism severity). The AWC samples from 67 preschoolers with ASD were collected during typical morning classroom routines (e.g., center time). Results indicated that AWC was positively associated with children's cognitive ability and negatively associated teacher burnout and adult to student with ASD ratio. Lower adult to children with ASD ratio (i.e., fewer adults relative to students with ASD) resulted in preschoolers receiving less adult language. Additional factors thought to be related to child and classroom characteristics affecting the adult language directed at children with ASD are discussed.

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## 1. Introduction

A rich, supportive language environment is associated with gains in the social and communication competencies typically developing children need for success in the preschool classroom and beyond (Burchinal et al., 2008; Mashburn et al., 2008). Adult language (or "output") is a fundamental component of the language environment and appears to be an underlying factor enabling the acquisition of these skills. These tenets, recognizing the importance of both the environment and the role of adult responsiveness to child communication, are key components of the transactional theory of language development. Transactional theory emphasizes the bidirectional nature of communication development, with the responsiveness of adults to children and their reciprocal interactions playing a vital role in development (Kublin, Wetherby, Crais, & Prizant, 1989). For example, the amount of teacher verbalizations children are exposed to in early childhood settings is positively associated with their sociability (Phillips, McCartney, & Scarr, 1987). Teachers' use of conversational control questions (e.g., Wh-questions) has been reported to produce more diverse and complex language among young children (Girolametto, Hoaken, van Lieshout, & Weitzman, 2000). Adult language is therefore likely to be

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even more beneficial for preschoolers with autism spectrum disorder (ASD), since it may play a role in ameliorating social-communication impairments (Warren & Yoder, 2004).

While adult language may be crucial for symptom improvement, there is some research to suggest that it varies greatly in preschool programs serving children with ASD. For example, Dykstra et al. (2012) reported that the number of adult words children with ASD are exposed to in preschool classrooms ( $n = 15$ ) over a 3 h period ranged from 1771–10,898 ( $M = 4886$ ). Although differences in program intensity, strategies, and methods likely affect this variability, knowledge is scant about child and classroom characteristics that may contribute to differences in the adult language children with ASD experience. With growth in the number of children with ASD entering the preschool classroom (Data Accountability Center, 2011), a better understanding of these factors will be important for early intervention efforts, as these factors may impact the reciprocal transactions, and ultimately may have effects on development in communication and other developmental areas.

There is evidence that certain child characteristics affect the adult language young children experience. Warren et al. (2010) used the Language ENvironment Analysis (LENA), a newly developed automated recording device, to examine the natural language environment of the home for children with ASD in comparison to a normative sample of typically developing children. Their results indicated that, on average, typically developing children had more vocalizations (647) and conversational turns (146) with adults per day than children with ASD. Further, the caregiver report measures of children's ASD symptomatology were associated with the amount of words caregivers directed to children. In other words, children with fewer autistic symptoms received more language from adults. Interestingly, the caregiver report measures were more robustly correlated with the number of words children with ASD received than objective measures of their abilities, suggesting that perceptions of ability may uniquely contribute to the amount of language children with ASD receive from adults. Adding to these findings, Dykstra et al. (2012), also using the LENA, found that the severity of children's autistic symptoms influenced the adult–child interactions in the preschool classroom. Specifically, these authors found that children with ASD who had greater cognitive impairments produced fewer vocalizations in the classroom, and children with this disorder who had lower language and cognitive abilities experienced fewer words from adults. Thus, irrespective of the setting (i.e., home or classroom), it is reasonable to hypothesize that children with ASD who produce fewer vocalizations may in turn elicit fewer words from adults, which may affect their ability to take advantage of learning opportunities in these social contexts.

In addition to child characteristics, there is reason to believe that unique features of the classroom (i.e., adult stress level and adult to child ratio) may affect the adult language children experience. First, there is evidence that difficult parent–child interactions are related to stress level, which in turn, can affect children's language development (Magill-Evans & Harrison, 2001). For example, Noel, Peterson, and Jesso (2008) found that higher levels of parent stress were associated with lower receptive and expressive language abilities among disadvantaged children. These authors speculated that their results stemmed from the lower quality of the parent–child interactions. Pertaining to preschool classrooms, research suggests that teachers of students with ASD may experience high levels of stress (Hastings & Brown, 2002; Lecavalier, Leone, & Witz, 2006; Wisniewski & Gargiulo, 1997). Similar then to highly stressed parents, classroom adults may have diminished verbal interactions with children with ASD, which may affect the development of children's language skills. The ratio of adults to children within the classroom is another factor that may impact the amount of time adults have to verbally interact with individual children. Hestenes, Cassidy, Shim, and Hegde (2008) examined teacher–student interactions in both inclusive and non-inclusive classrooms and found that high adult to child ratios were associated with increased teacher responsiveness. Alternatively, low adult to child ratios have been found to be associated with teachers' use of more restrictive language (e.g., go to blocks, put on your shoes) with children (Cassidy & Buell, 1996; Hauser-Cram, Bronson, & Upshur, 1993), which could lead to fewer conversational turns between adults and children, particularly those with limited communication skills such as children with ASD. Thus, stress level and adult–child ratio appear to be related to adult–child interactions and are, therefore, likely to be particularly influential in classrooms containing children with ASD because of the challenges this disorder presents to teachers.

Although previous studies provide useful information about child and classroom characteristics that affect the adult language young children experience, several limitations are apparent. First, there is a dearth of knowledge about the relationship between child characteristics and the resulting adult language children with ASD experience in the classroom. Second, research on the link between the adult output received by children with ASD and features of the classroom (e.g., ratio of adults to children with ASD) is needed. To begin to address these deficits in the literature, the overall aim of this study was to examine the association between the LENA variable of adult word count (AWC) and characteristics of classrooms and preschoolers with ASD. The specific research questions were: (1) how does the number of adult words directed at children with ASD vary by severity of children's symptoms; and (2) what is the association between certain characteristics of classrooms (i.e., teacher burnout, adult to child ratio and adult–student with ASD ratio) and AWC.

## 2. Methods

### 2.1. Participants

Sixty-seven children, ages 3–5, who were part of a larger study examining preschool programs for young children with ASD were included in this study. All participating children were served in self-contained classrooms in a Southeastern school district in the United States. Of the 67 participants, 79% were male ( $n = 54$ ) and 7% ( $n = 5$ ) were Asian, 17% Black ( $n = 12$ ), and

**Table 1**  
Descriptives for continuous variables.

Variable	N	Mean	Standard deviation
AWC adjusted	67	31.94	11.00
SRS: total T score	66	66.82	10.50
RBS-R: total score	66	18.58	11.35
CTRF: total T score	66	61.47	7.47
CARS: total score	66	35.42	8.18
PLS4: standard score	66	68.79	19.97
Mullen: visual reception T score	64	33.20	16.18
Adult to child ratio	21	0.30	0.12
Adult to student with ASD ratio	21	7.15	2.06
MBI: total score	21	29.45	18.34

73% White ( $n = 50$ ). Parents also were asked to identify their child's ethnicity (i.e., whether or not they were Hispanic) in addition to identifying the child's racial group status. Sixteen percent ( $n = 11$ ) of participants' parents identified their children's ethnicity as Hispanic. All children in the study had a prior educational or community diagnosis of either ASD or developmental delay, and met diagnostic criteria for ASD on the most recent ADOS algorithms (Gotham, Pickles, & Lord, 2009). The participants had varying levels of autistic symptoms, as well as social, verbal and cognitive abilities (see Table 1).

A total of 21 high quality preschool classrooms were included in the study. Classrooms were screened for study inclusion by trained observers to ensure overall quality using a psychometrically validated tool, i.e., the Professional Development in Autism Program Assessment (Professional Development in Autism Center, 2008). Specifically, all classrooms had to meet an "average" rating (score of 3 out of 5) on four subscales of the PDA assessment during an initial classroom visit. These subscales included classroom structure, classroom environment, curriculum and instruction, and positive instructional climate. Further description of this measure can be found in section 2.5. All classroom teachers were female and White ( $n = 21$ ) as well as certified to teach in preschool classrooms. Twelve of the teachers had bachelor's degrees and nine teachers had master's degrees. The mean teaching experience for the sample was 11.02 years ( $SD = 8.67$ ).

## 2.2. LENA system

The LENA yields three language-related variables: Adult Word Count (AWC), Child Vocalizations (CV), and Conversational Turns (CT). AWC represents the adult words spoken to or near the child (within a 6 foot radius), but excludes overlapping adult and child speech, TV, and radio. LENA also provides the proportion of meaningful data, referring to vocalizations and speech-related sounds captured during the recording. The reliability and validity of LENA has been extensively tested with typically developing infants and young children in the home environment (Xu, Yapanel, & Gray, 2009), and its use in school and home settings with young children with ASD is expanding (Dykstra et al., 2012; Warren et al., 2010). A recent study examined the reliability of the LENA for use in preschool classroom settings (McCauley, Esposito, & Cook, 2011). Five-minute segments from 30 recording sessions in preschool classrooms for young children with and without ASD were coded by an observer and compared to LENA counts. Total correlation between the observer and LENA estimates was 0.81 ( $p < 0.01$ ) across the adult, child, and other variable categories. Inter-rater reliability was calculated on 12% of the recordings and the agreement for AWC was 91.9%. 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.

## 2.3. Child characteristics: severity and autistic symptoms measures

A summary of the purpose and psychometric properties of each measure of child characteristics found in Appendix A.

*Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavore, & Risi, 1999)* is a semi-structured assessment considered to be the gold standard diagnostic instrument for ASD, with four different modules administered depending on the age and language abilities of the individual. 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.

*Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Renner, 1988)* is an instrument designed to assess children's behaviors (e.g., relating to others, fear, nonverbal communication) in order to distinguish children with ASD (age 2 through adulthood) from those children who have a developmental delay. Scores range from 15 to 60 and are based on a four-point scale. Higher scores indicate more severe symptoms of autism. Total scores were used in data analysis for this study. Research trained staff scored the CARS while observing the child in a free play scenario at school.

*Social Responsiveness Scale (SRS; Constantino & Gruber, 2005)* is a 65-item teacher/caregiver reported measure where each item is scored from 1 = not true to 4 = almost always true. The instrument assesses severity of social symptoms children with autism possess by providing information about his/her social impairments, social awareness, social information processing,

capacity for reciprocal social communication, social anxiety/avoidance, and autistic preoccupations and traits. The tool is designed to be used with children aged 4–18 years. The total T-scores based on teacher-report were used in data analysis.

*Repetitive Behavior Scale-Revised (RBS-R; Bodfish, Symons, & Lewis, 1999)* is a 42-item caregiver/teacher report that assesses 43 distinct types of repetitive behaviors across six subscales: stereotypy, self-injurious behavior, compulsions, rituals, sameness and restricted interests. Scores for each item on the measure range from 0 (behavior does not occur) to 3 (behavior occurs and is severe). Higher scores indicate more repetitive behaviors. For the current study, total scores from forms filled out by teachers were used for data analysis.

#### 2.4. Child characteristics: developmental and behavioral measures

*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. For the purposes of this study, scores from the visual reception (VR) subscale T-score were used to estimate nonverbal cognitive ability, allowing for the separation of language from cognitive ability. For the current sample, the VR subscale was highly correlated with the overall Mullen score ( $r = 0.93, p < 0.0001$ ).

*Caregiver-Teacher Rating Form (C-TRF; Achenbach & Rescorla, 2000)* is a teacher/caregiver report measure used to assess emotional and behavioral problems and consists of an internalizing and externalizing scale. The tool is appropriate for children 1.5–5 years old. There are 99 problem items that can be rated as 0 (not true) to 2 (very true or often true). Total T-scores were used in data analysis.

*Preschool Language Scale (PLS-4; Zimmerman, Steiner, & Pond, 2002)* is a tool 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 standard scores based on the total language score of the PLS-4 were used to estimate communication abilities.

#### 2.5. Classroom features measures

*Maslach Burnout Inventory-Educators Survey (MBI-ES; Maslach, Jackson, & Leiter, 1996)* contains 22-items on a 7-point continuum (0 = never, 6 = every day). Teachers rate their daily feelings that fall within the following three subscales: Emotional Exhaustion, Depersonalization, and Personal Accomplishment. The MBI-ES total score was computed by subtracting the score on the personal accomplishment subscale from the maximum possible score (48) and adding to it the emotional exhaustion and depersonalization subscales scores. By reverse scoring the personal accomplishment subscale, we ensured that higher scores on the MBI-ES represent higher levels of burnout.

*Professional Development in Autism Program Assessment (PDA; Professional Development in Autism Center, 2008)* measures features of quality in programs for learners with ASD. This measure is intended to evaluate general classroom (e.g., physical space) and program quality (e.g., positive instructional climate) in classrooms serving children with ASD. The PDA Program Assessment is a checklist containing 54 items representing eight domains. The measure is scored using a 5-point scale (5 = full implementation, 1 = minimal/no implementation). The PDA is a psychometrically sound instrument with strong internal consistency ( $\alpha = 0.94$ , with a range across subscales of 0.71–0.95), test–retest reliability (ICC = 0.83, range and 0.53–0.87), and validity demonstrated through descriptive discriminant analysis, which indicated that its subscales could accurately discriminate between classroom types (Hume et al., 2009).

#### 2.6. Procedure

Research staff conducted the direct child assessments at children's schools during the beginning of the school year. Teacher report data were collected by dropping off and picking up assessment packets at the child's school. Across the three data sources (parent, teacher and child), we collected all data on an individual child within a 6-week time window.

For LENA recordings, the researchers inserted the LENA digital language processor (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 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 typically wore the vest for no more than 3 h on one school day, 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 one school day ( $n = 67$ ). The duration of recording for the LENA device was, on average, 168.17 min (SD = 28.4).

The adjusted adult word count (AWC adjusted) variable was created by dividing the total number of adult words counted by the LENA device by the duration of the recording in minutes. This was done because the duration of the LENA recordings varied across children. Therefore, the AWC adjusted variable represents the average number of adult words per minute heard by the child during the recording period. This variable served as the outcome in all analyses. Because AWC is a rate, it can only take on discrete values and cannot take on values less than zero. The adult to child ratio variable was calculated by dividing the number of adults by preschoolers per classroom, and the same calculation was done for adults to preschoolers with ASD.

**Table 2**  
Child characteristics correlations.

Variable	Label	AWC	SRSP	RBSR	CTRF	CARS	PLS4	Mullen VR
AWC	Adult word count, adjusted	1						
SRS	SRS: total T score	0.02	1					
RBSR	RBS-R: total score	0.08	0.67*	1				
CTRF	CTRF: total T score	0.08	0.69*	0.53*	1			
CARS	CARS: total score	0.01	0.55*	0.27*	0.39*	1		
PLS4	PLS4: standard score	0.22	-0.45*	-0.30*	-0.47*	-0.49*	1	
Mullen	Mullen: visual reception T score	0.25*	-0.38*	-0.24	-0.37*	-0.52*	0.81**	1

\*  $p < 0.05$ .\*\*  $p < 0.01$ .**Table 3**  
AWC by child characteristics ( $n = 64$ ).

Variable	Estimate	Standard error	$p$
Intercept	31.702	1.350	<0.0001
CARS: total score	0.152	0.208	0.4683
PLS4: standard score	0.081	0.115	0.4832
Mullen: visual reception T score	0.125	0.147	0.3981

 $R^2_{adj} = 0.03$ . All variables centered.

### 3. Results

**Research Question 1:** How does the number of adult words directed at children with ASD vary by severity of children's symptoms? Correlations were used to examine the concurrent associations between AWC and the baseline standardized measures (i.e., Mullen-VR, PLS-4, RBS-R, CARS, CTRF, SRS). Ordinary least squares (OLS) regression was used to examine the relationships between AWC and autism severity, language and cognitive ability (i.e., CARS, PLS-4 and Mullen-VR). There was a significant positive correlation ( $r$ ) between the AWC LENA variable and the Mullen-VR ( $r = 0.25$ ), using a cut-off of  $p = 0.05$ . Thus, preschoolers with ASD who had less severe cognitive difficulties were exposed to more words from adults. The remaining correlations between AWC and developmental ability measures and autism severity and symptoms were not significant. In the regression model, no parameters reached statistical significance. The complete results are displayed in Tables 2 and 3.

**Research Question 2:** What is the association between certain characteristics of classrooms (i.e., teacher burnout, adult to child ratio and adult to student with ASD ratio) and AWC? We used correlations and OLS regression to examine the relationships between AWC and teacher burnout, adult to child ratio (i.e., total number of children in the classroom relative to adults) and adult to student with ASD ratio. There were significant negative correlations between the AWC LENA variable and classrooms features, using a cut-off of  $p = 0.05$ . Specifically, the AWC rates were negatively correlated with teacher burnout ( $r = -0.28$ ) and adult to student with ASD ratio ( $r = -0.39$ ). In other words, increased levels of teacher burnout (MBI-ES measure) and lower adult to student with ASD ratios were associated with children with this disorder receiving fewer words from adults. In

**Table 4**  
Classroom characteristics correlations.

Variable	Label	AWC	Ratio	ASD size	MBI
AWC	Adult word count, adjusted	1			
Ratio	Adult to child ratio	-0.04	1		
ASD size	Adult to student with ASD ratio	-0.39*	-0.04	1	
MBI	MBI: total score	-0.28*	0.07	0.46*	1

\*  $p < 0.05$ .**Table 5**  
AWC by classroom characteristics ( $n = 21$ ).

Label	Estimate	Standard error	$p$
Intercept	31.827	1.276	<0.0001
Adult to child ratio ( $\times 10$ )	-0.410	1.038	0.6943
Adult to student with ASD ratio	-1.977	0.787	0.0146*
MBI: total score	-0.074	0.076	0.3338

 $R^2_{adj} = 0.12$ . All variables centered.\*  $p < 0.05$ .

the regression model, class size for the ASD variable had a negative and significant relationship with adjusted AWC ( $B = -1.997, p = 0.01$ ), indicating that AWC tends to decrease as more students with ASD are added to the classroom. See Tables 4 and 5 for complete results.

#### 4. Discussion

The purpose of this study was to examine the relationship between child and classroom characteristics and the adult language used in preschool classrooms serving young children with ASD, and thus provide preliminary data to guide future discussions on the transactional model of communication development and its impact on students with ASD. Our results indicated that child and classroom characteristics were related to the number of adult words. Children with ASD who had more cognitive difficulties were exposed to fewer words from adults. Classroom setting characteristics that resulted in lower amounts of adult language were higher teacher burnout levels and lower adult to student with ASD ratio (i.e., fewer adults relative to children with ASD). It is important to note the strength of these associations ranged from small to medium.

##### 4.1. Child characteristics and AWC

Previous research suggests children with disabilities are the recipients of different amounts and types of adult language compared to their typically developing peers. Hestenes, Cassidy, and Niemeier (2004) study of teacher output in inclusive classrooms relied on 2 h recordings of 186 preschoolers and found that children were the recipients of 18,206 statements or questions. The authors noted, however, that teachers directed more verbalizations at typically developing children (11,105) than children with disabilities (7005). Alternatively, Brown, Odom, Li, and Zercher (1999) examined adult behavior toward children with and without disabilities during center-time and found that adults provided children with disabilities with more support (e.g., assisting with transitions) than typically developing children. These studies suggest results are mixed as to whether children with disabilities receive more or less adult language than their typically developing peers. That said, our findings add to the literature by demonstrating that as disability (i.e., cognitive impairment) becomes less severe adult language tends to increase.

This finding may result from selected teaching strategies thought to benefit children with ASD. Some teaching strategies for children with ASD, such as structured teaching, encourage adults to use fewer/simpler words and phrases with children with ASD and visual supports to increase the likelihood of language comprehension (Hume, Turner-Brown, Boyd, & FITT Study Team, 2012; Mesibov, Shea, & Schopler, 2004). Thus, it is possible that teachers were using more nonverbal forms of communication, such as visual strategies, to promote children's social-communication. Similarly, other methods and models encourage the "one-up" rule when communicating with young children with ASD. The Early Start Denver Model manual, for example, describes this strategy as "the mean length of the adult's utterances is approximately one word longer than the mean length utterance of the child's utterance" (Rogers & Dawson, 2010, p. 25), thus children with less language or shorter utterances (often those with increased cognitive impairments) may be exposed to fewer words from adults.

Another possibility, offering some support for transactional effects of language development, is that children with lower cognitive abilities may not seek out adults to interact with to the degree that their higher functioning peers do, and thus may not be eliciting adult language. This knowledge adds to existing research by providing information about how the severity of a student's disability can impact the amount of adult words children with ASD experience. Further, this information may help special education teachers and allied health service providers, both current and pre-service, become more aware of how severity can impact the amount of language they provide to children on the autism spectrum. It is important to note, however, that because this type of research is in its infancy, one cannot yet determine that exposure to fewer adult words is negatively associated with the developmental outcomes of those students with increased cognitive impairment. This finding requires further investigation, as it is possible that exposure to limited, yet planned and purposeful language may have the same or more benefits than more, possibly less meaningful language from adults.

##### 4.2. Classroom characteristics and AWC

There is also research suggesting that characteristics of classrooms (i.e., teacher burnout and adult to child ratio) can impact adult–student interactions. For example, Jennett, Harris, and Mesibov (2003) stated that, "although all special education teachers are potentially at risk for burnout because of the challenging nature of their students, teachers of students with autism may be especially at risk . . . [because] these children have a unique set of characteristics setting them apart from other special needs children.... (p. 584)." Our findings indicated that teachers who were experiencing burnout provided children with ASD with fewer words. It is difficult to discern the causality or direction of this pattern of behavior – it is unknown if the teacher is first experiencing burnout, then demonstrating withdrawal indicated by reduced language and verbal interaction, or if the difficulty in verbally interacting with students who may often be unresponsive then contributes to burnout and a reduction of words. The literature around parent stress (akin to teacher burnout) indicates that parents of children with ASD who are more responsive experience less parenting stress (Kasari & Sigman, 1997). Parallels in teaching may therefore occur for those working with children who are less responsive, thus leading to an increase in burnout and decrease in teacher output. This is of concern since both theory (i.e., the transactional theory of language development) and empirical evidence (e.g., Girolametto et al., 2000) suggest that decreases in certain types of adult output may affect children's

language development. Teacher burnout is a commonly recognized issue in special education (Cherniss, 1995); however this is the first examination of its potential impact on and relationship with the quantity of language classroom adults direct to students with ASD.

There are varied findings in the literature on the impact of adult to child ratio on classroom interactions between students and classroom staff. Some authors report a minimal or absent relationship between adult to child ratio and the quality of interactions between adults and preschoolers (Mashburn et al., 2008; Pianta et al., 2005). reported that adult to child ratio was not associated with the quality of interactions between adults and preschoolers. Conversely, other researchers have found that as the ratio of students to adults increases, the quality of interactions tend to diminish (File & Kontos, 1993; Hestenes et al., 2008). For example, Hestenes and colleagues found that positive teacher behaviors (e.g., responsiveness, praise) decreased as the ratio of children to adults increased. Our results indicated that higher numbers of children with ASD relative to adults was associated with fewer adult words directed to these children and, therefore, the possibility of fewer adult directed supportive interactions. A number of factors may contribute to this finding, including the limited resources or time teachers that are serving many students with ASD commonly experience (Naylor, 2002), which may contribute to shorter or fewer verbal interactions. In addition, and described previously, students with ASD may be less likely to respond to adult vocalizations and initiate interactions (Warren et al., 2010); thus in a classroom serving more students with ASD, verbal output from teachers may be limited.

#### 4.3. *Limitations*

This study has several limitations that must be noted. First and foremost, the AWC variable provides only a count of adult verbalizations, so information on the type or quality of verbalization is not captured. In addition, it does not provide information on other supports that staff members may have used instead of language (e.g., gestures, visual cues, facial expressions). While the AWC variable provides an accurate representation of adult words, it may underestimate the communicative behavior adults demonstrate toward their students. Similarly, peer-to-peer interaction, a valuable component of language development, was not captured in this study. Second, since these were all high quality self-contained classrooms, generalizations to inclusive and/or lower quality classrooms serving preschoolers with ASD cannot be made. The LENA has a 6 ft. radius in which it captures audio data; therefore, it is possible that adults were vocalizing near focal children, but not necessary directing words toward them. Lastly, our LENA data came from one time period so whether adult language is similar at other times during the school year is unknown. In order to make more concrete claims about the adult output directed at children with ASD in the preschool classroom additional observational measures are needed (i.e., video). Despite these limitations, the current study does provide meaningful information about child and setting factors affecting the language environment in classrooms serving preschoolers with ASD.

#### 4.4. *Future directions*

The LENA system offers a reliable and efficient method for capturing the adult output to which young children are exposed, which is essential for understanding factors that may impact bi-directionality in classroom communication. Further, the results of this study demonstrate that this device can be used in combination with child and environmental measures to better determine how the ecological features of the classroom impact adult verbalizations. This study begins the discussion around the role of adult language in classrooms serving young children with ASD and specifically addresses the influence of child and classroom characteristics on the amount of language used. Questions around the optimal amount of language for students with ASD at varying levels of functioning as well as the role of adult language in the development of young children with ASD remain. Future studies that examine these issues are required, as well as studies examining how classroom characteristics contributing to decreased AWC can best be moderated. With LENA's ability to efficiently capture data, researchers should consider using the device as an intervention tool to provide adults with ongoing performance feedback related to the amount of language they direct at children with ASD, particularly when certain setting (e.g., teacher burnout) and child characteristics are present. Studies that use the LENA as well as observational measures to capture the adult nonverbal communication directed at young children with ASD could provide a more holistic glimpse of the natural preschool language environment. Lastly, expansion of the current work into home settings and/or across the school setting may offer a more complete picture of the language environment for young children with ASD. This knowledge could lead to a better understanding of transactional theory and its impact on development in children with ASD, as well as the development of innovative and sustainable language interventions for classroom personnel and caregivers.

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## Appendix A. [(Appendix A)]

Measure	Brief description of use in study	Psychometric properties
<i>Autism Diagnostic Observation Schedule</i> (ADOS; Lord et al., 1999)	Confirm the diagnosis of autism or ASD	Alpha coefficients are 0.86–0.91 for the social domain (across modules), 0.74–0.84 for communication, and 0.63–0.65 for repetitive behaviors (modules 1 and 2) (Lord et al., 2000)
<i>Caregiver-Teacher Rating Form</i> (C-TRF; Achenbach & Rescorla, 2000)	Teacher report of behavior and emotional problems	Internal consistency reliability ranges from 0.90 for the total score, and from 0.72 to 0.95 for subscale scores
<i>Childhood Autism Rating Scale</i> (CARS; Schopler et al., 1988)	Describe symptom severity	Internal consistency of the CARS was high, with a coefficient alpha of 0.94 (Schopler et al., 1988)
<i>Mullen Scales of Early Learning</i> (MSEL; Mullen, 1995)	Monitor children's general developmental outcomes across visual reception, fine motor, expressive/receptive communication skills	Internal reliability ranges from 0.71 to 0.83 across MSEL subtests, and 0.91 for the overall developmental score
<i>Preschool Language Scale, 4rd Edition</i> (PLS-4; Zimmerman et al., 2002)	Gather information about children's receptive and expressive language	Internal consistency reliability coefficients range from 0.66 to 0.96
<i>Social Responsiveness Scale</i> (SRS; Constantino & Gruber, 2005)	Teacher report of child's social initiations and reciprocity	Internal consistency is 0.93 for overall score
<i>Repetitive Behavior Scales-Revised</i> (RBS; Bodfish, Crawford, Powell, & Parker, 1995; Bodfish et al., 1999)	Teacher report of child's repetitive behavior	Alpha values for the five subscales ranged from 0.78 to 0.91

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