RESEARCH ARTICLE

Learning Language in Autism: Maternal Linguistic Input Contributes to Later Vocabulary

Janet Bang and Aparna Nadig

It is well established that children with typical development (TYP) exposed to more maternal linguistic input develop larger vocabularies. We know relatively little about the linguistic environment available to children with autism spectrum disorders (ASD), and whether input contributes to their later vocabulary. Children with ASD or TYP and their mothers from English and French-speaking families engaged in a 10 min free-play interaction. To compare input, children were matched on language ability, sex, and maternal education (ASD $n = 20$, TYP $n = 20$). Input was transcribed, and the number of word tokens and types, lexical diversity (D), mean length of utterances (MLU), and number of utterances were calculated. We then examined the relationship between input and children's spoken vocabulary 6 months later in a larger sample (ASD: $n = 19$, 50–85 months; TYP: $n = 44$, 25–58 months). No significant group differences were found on the five input features. A hierarchical multiple regression model demonstrated input MLU significantly and positively contributed to spoken vocabulary 6 months later in both groups, over and above initial language levels. No significant difference was found between groups in the slope between input MLU and later vocabulary. Our findings reveal children with ASD and TYP of similar language levels are exposed to similar maternal linguistic environments regarding number of word tokens and types, D, MLU, and number of utterances. Importantly, linguistic input accounted for later vocabulary growth in children with ASD. ***Autism Res** 2015, 8: 214–223*. © 2015 International Society for Autism Research, Wiley Periodicals, Inc.

Keywords: linguistic environment; parental input; maternal speech; lexical features; MLU; language development; autism spectrum disorders

Introduction

Children make use of the wealth of linguistic information available in daily interactions to advance their language development [Hart & Risley, 1995; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991; among others]. The ambient linguistic environment parents produce has been referred to as language input (henceforth input). Different features of the input have been examined, ranging from measures of grammatical complexity such as the mean length of utterance (MLU), to lexical features such as the number of different words produced (word types). Importantly, these input features have been shown to predict children's later language abilities [e.g., Hoff & Naigles, 2002; Hurtado, Marchman, & Fernald, 2008; Rowe, 2012]. This reveals that children implicitly keep track of language input and develop better language abilities when immersed in rich input environments. For instance, the overall number of words (word tokens) in the input is associated with the rate of children's vocabulary development, as well as the speed of later vocabulary processing [Hurtado et al., 2008; Huttenlocher et al., 1991], and word types and MLU are predictive of children's later vocabulary [Hoff & Naigles, 2002].

These findings underscore the value of input for typical language development, but we know less about language development in autism spectrum disorders (ASD). ASDs are characterized by deficits in social communication and interaction, and by the presence of restricted repetitive and stereotyped interests [American Psychiatric Association, 2013]. Children with ASD experience atypical language development and often language delay [Kjelgaard & Tager-Flusberg, 2001; Zwaigenbaum et al., 2005]. Given their social impairments, a large body of research on ASD has focused on social contributors to children's later language abilities. For instance, children's ability to use explicit social cues [e.g., pointing, labeling; McDuffie, Yoder, & Stone, 2005; Mundy, Sigman, & Kasari, 1990] and parental input that follows their child's attention [e.g., McDuffie & Yoder, 2010; Siller & Sigman, 2002, 2008] have both been shown to be related to later language. However, the ambient linguistic environment

From the School of Communication Sciences and Disorders, McGill University, Montreal, Quebec, Canada (J.B., A.N.); Centre for Research on Brain, Language & Music, McGill University, Montreal, Quebec, Canada (J.B., A.N.)
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Address for correspondence and reprints: Janet Bang, School of Communication Sciences and Disorders, McGill University, 2001 Avenue McGill College Suite 800, Montreal, Quebec H3A 1G1, Canada. E-mail: janet.bang@mail.mcgill.ca
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itself provides a rich source of information for language learning, without explicit instruction. Little is understood regarding (a) the quality of the linguistic environment available to children with ASD and (b) whether children with ASD can use this linguistic information to increase their vocabulary, as has been shown in typical development. To address this gap, we provide a detailed comparison of the linguistic input available to children with ASD and typically developing children and investigate predictive relationships between input and children's later spoken vocabulary.

Parental Input Features in ASD

Four studies to date have analyzed the linguistic content of the input provided by parents of children with ASD and parents of typically developing children [Swensen, 2007; Warren et al., 2010; Wolchik & Harris, 1982; Wolchik, 1983]. Wolchik [1983] compared the input of 10 mothers and 10 fathers of children with ASD matched with mothers and fathers of children with typical development on parent education, child language ability, and sex. No differences were seen between diagnostic groups for MLU, although parents of children with ASD were found to produce significantly more utterances than parents of typically developing children. Swensen [2007] reported that the maternal use of word types did not differ between diagnostic groups matched on language ability. In addition, Warren et al. [2010] found that total adult word counts did not differ between diagnostic groups matched on maternal education, child chronological age, and sex; however, diagnostic groups were not matched on child language ability. These studies provide an important first look at the language-learning environment available to children with ASD.

We build on this literature by providing a comprehensive comparison of multiple features of the input produced by mothers of children with ASD and those of typically developing children, including those previously examined (i.e. word tokens and types, MLU, number of utterances), and one not previously explored in ASD (i.e. lexical diversity as measured by D, see p. 10). For the first time, we conduct this comparison in a language other than English, in both English and French-speaking families. Though we do not expect differences in input across these two languages for typological or other reasons, we analyze the data separately for completeness, as this is the first investigation to our knowledge of linguistic input to children with ASD in a language other than English. Based on previous research [Swensen, 2007; Warren et al., 2010; Wolchik & Harris, 1982; Wolchik, 1983], we predicted that there would be no differences in input features between mothers of children with ASD and mothers of typically developing children.

Relationships Between Input and Later Child Vocabulary in ASD

In a seminal study on the impact of input on typical child language development, Huttenlocher et al. [1991] found that variation in word tokens was associated with differential rates of vocabulary growth, as well as later spoken vocabulary in children 14–26 months old. Since then, reports have consistently shown that various linguistic features of the input (e.g. MLU, word tokens, and word types) are significant predictors of children's later vocabulary [e.g. Hart & Risley, 1995; Hoff & Naigles, 2002; Hurtado et al., 2008].

Studies have begun to explore the relationship between linguistic input and later child language in ASD. In 26 children with ASD aged 16–48 months, Warren et al. [2010] demonstrated that higher parental word counts (determined by a digital language processor) were significantly correlated with increased child vocabularies 7 weeks later, although their analysis did not control for initial child language abilities. Swensen [2007] utilized a series of partial correlations to examine longitudinal associations between maternal input and later child language while controlling for variables such as child MLU, maternal MLU, and maternal IQ in 10 children with ASD. Maternal noun types were significantly and positively associated with multiple later child language measures (e.g. word tokens and types, use of past tense). Rollins and Snow [1998] found a negative correlation between the number of utterances spoken by parents and children's later expressive morphosyntax in six dyads of parents and children with ASD. In sum, evidence is emerging that input can influence later child language in ASD, as is well established in typical development.

In the present study, we used a hierarchical multiple regression model to examine whether input features are predictive of spoken vocabulary approximately 6 months later in 19 children with ASD and in 44 typically developing children from both English and French-speaking families. As with our prior hypothesis for comparisons of parental input between language groups, we do not expect language to be a significant predictor in our model; if language is not a significant predictor, the final model will be presented without language to increase power. To compare the relationship between input and later vocabulary between groups, we included an interaction factor, input*diagnostic group. Based on prior studies in both ASD [Swensen, 2007; Warren et al., 2010] and typical development [e.g. Hoff & Naigles, 2002], we predicted that after controlling for concurrent child language, input features would contribute to spoken vocabulary in both diagnostic groups.

Method

Participants

Participants were dyads of mothers and their children with either ASD ($n = 20$) or typical development (TYP, $n = 44$). Families were recruited in Montreal, Canada and were either English speaking (EN) or French speaking (FR), defined by parent report of language exposure of more than 75% of the respective language. Children with ASD were recruited through a hospital clinic, daycares, camps, and flyers. Diagnoses were established through a multidisciplinary assessment including the Autism Diagnostic Observation Schedule [ADOS; Lord, Rutter, DiLavore, & Risi, 2002], which was administered by a clinical psychologist or psychiatrist; all met criteria for autism or ASD. Our final ASD sample included 20 children and their mothers. Nine additional families were not included because two dropped out after the first of three study visits, two dropped out after the second visit, one did not meet inclusion criteria, one was the sister of another child with ASD in the sample, and three participated with father–child dyads[1].

Typically developing children were recruited from a university research database. Inclusion criteria were: no developmental, learning, or behavioral disorder by parent report; no history of significant medical complications or conditions; no first or second-degree relatives with an ASD. Our final sample included 44 typically developing children and their mothers. Nine additional families were not included because three dropped out after the first of three study visits, and six dropped out after the second visit.

The analysis of parent input features was conducted on data from our 20 ASD dyads and a matched subset of 20 TYP dyads. Relationships between input and later child vocabulary were conducted within groups for all participants who had language outcome data at their third visit, resulting in samples of 19 ASD dyads and 44 TYP dyads.

Procedure

Families participated in a larger longitudinal study, which included three time points over the course of a year. The data collected for the present study were obtained at the second (T2) and third visit (T3). T2 took place at a university lab or in the participant's home, depending on the family's preference. At this visit, the parent and child were videotaped in a 10 min free play interaction with a set of standardized toys that included two dolls, a tea set, blocks, a dump truck, and a toy cell phone. Parents were asked to play with their child as they normally would while trying to stay on a blanket approximately 4×4 square feet. The T3 visit occurred approximately 6 months following the T2 visit (M = 6.57, SD = 1.02). At the T3 visit, parents completed the MacArthur-Bates Communicative Development Inventories (MCDI) Infant Form—Words and Gestures [Fenson et al., 2007] or the French adaptation Inventaire MacArthur-Bates du développement de la communication: Mots et Gestes [Trudeau, Frank, & Poulin-Dubois, 1999]. Ethical approval was obtained from a university institutional review board, and informed consent was obtained from families prior to study participation.

Transcription. Full transcripts are available online (http://www.childes.psy.cmu.edu/data/Clinical/). Three native EN and three native FR (native Quebec French speakers), undergraduate and graduate students transcribed the interactions using conventions provided by the Codes for the Human Analysis of Transcripts (CHAT) transcription program [MacWhinney, 2000]. All transcribers except the first author were blind to child diagnosis and other demographic variables. Children from each diagnostic group, and those of high and low language ability were equally distributed among transcribers. Each interaction was viewed independently by two transcribers. The first transcriber completed the transcription, which was then reviewed by a second transcriber; all transcribers served as both first and second transcribers on different files. The second transcriber reviewed the video of the interaction for utterance breaks, attention to deciphering unintelligible utterances, and adherence to CHAT conventions. Any major discrepancies with the original transcription were noted on a protocol sheet for discussion. No major discrepancies were found. Utterances were determined by either clear intonational markers such as questions or exclamations, or by a clear pause followed by a breath. When all transcripts were completed, the FREQ program was run using the Computerized Language ANalysis [CLAN; MacWhinney, 2000], and all lexical items were reviewed and corrected to ensure orthographic consistency. Then, the MOR and POST programs were used to process the corpus and provide the morphemes per line in the transcript.

Measures

Parental input. Analyses were derived from nine full minutes of interaction, except for four dyads (ASD $n = 2$ and TYP $n = 2$, range = 4.80 to 8.5 min). These cases were included on the basis that they reflected real variation in parents' input [Hoff-Ginsberg, 1992]. Number of word tokens and types, D, MLU (in morphemes), and number

[1]In our complete sample, three father–child dyads participated in the ASD group while no father–child dyads participated in the TYP group. The fathers in our sample had fewer word types than mothers (mean types fathers = 98.70; mean number of word types mothers = 151). Given that fathers were only represented in one of our groups, our word types finding as well as previous research reporting that fathers provide less input than mothers [Pancsofar & Vernon-Feagans, 2006], we did not include father–child dyads in our analyses.

of utterances were computed using CLAN [MacWhinney, 2000]. Word tokens provide the total number of words spoken, while word types reflect the number of different words spoken. D is a measure of lexical diversity that is calculated from repeated random sampling of words [VOCD program; McKee, Malvern, & Richards, 2000]; D is not affected by variation in sample size, thus allows for better comparison across individuals and studies in comparison to a type-token ratio. Word tokens, word types, and D were derived from the lemmatized form of the word (e.g. "run" and "running" both counted as instances of the same stem "run"). Lexical items determined to be communicators with no lexical meaning (e.g. ah, hmm) were not included.

Child language. At T2, child language was measured by children's word types during the parent–child interaction; word types were calculated in the same manner as parental word types, just described. At T3, child spoken vocabulary was measured with the MCDI Infant-Words and Gestures form [Fenson et al., 2007] or its French equivalent [Trudeau et al., 1999], a parent checklist of preverbal communicative skills and specific words understood and produced by children. Because the total number of vocabulary words differs in English (396) and French (408) versions, we report the percentage of raw vocabulary words (words produced out of the total possible). The MCDI Infant form was developed for typically developing children aged 8–18-months old, which is considerably younger than our sample. However, given characteristic delays in preverbal skills and vocabulary in ASD, this form was selected to measure change on the same items between T1 and T3 in children with ASD, for whom the Words and Sentences form was too advanced. As a result at T3, there are children with ASD and typically developing children (selected to be comparable to language ability with children with ASD) who are close to ceiling on this measure. This did not preclude our ability to find significant input predictors while using the MCDI as an outcome measure.

Diagnostic confirmation. The ADOS [Lord et al., 2002] is a semi-structured assessment designed to assess children's social communication abilities and other behaviors associated with ASD. Children in our sample were administered Module 1 or 2.

Results

Parental Input Features

Group matching. For this comparison, a matched subset of 40 mother–child dyads was selected from our entire sample. Demographic information and matching results are provided in Table 1. For each of our ASD participants, we selected a TYP participant who spoke the same language, and to the extent possible was of the same sex and had a similar maternal education. Our final sample for this analysis included 20 ASD dyads who did not significantly differ from 20 TYP dyads on the variables of T2 child word types, child sex, and maternal education [as a proxy for socioeconomic status (SES); Ensminger & Fothergill, 2003]. Because studies have found that maternal language is sensitive to children's spoken language [e.g., Snow, 1972, among others], children were matched on spoken vocabulary (i.e. word types). Child word types were used to match groups on language ability rather than type-token ratios because prior research has found word types to be a more sensitive measure in differentiating typically developing children from those with language impairment [Watkins, Kelly, Harbers, & Hollis, 1995]. As expected, since we selected participants who would be similar in language ability, the ASD group was significantly older than the TYP group at T2 in both EN and FR samples.

Analyses. Statistical analyses were conducted in R version 3.03 [R Core Team, 2013]. Two (diagnostic group) x two (language) analyses of variance (ANOVAs) were conducted for (a) word tokens, (b) word types, (c) D, (d) MLU, and (e) number of utterances. All assumptions of ANOVA were satisfied, including approximately normal

Table 1. Child and Parent Demographic Data for Parental Input Comparison $n = 40$

	English speaking			French speaking		
	ASD ($n = 11$)	TYP ($n = 11$)	P	ASD ($n = 9$)	TYP ($n = 9$)	P-values
Child sex (M : F)	9:2	8:3	1.00	5:4	5:4	1.00
T2 child word types[a]	48.46 (42.48) 0–117	59 (34.36) 0–98	0.53	56.44 (39.39) 11–125	65.67 (25.30) 17–98	0.61
Maternal education (below university: university degree: beyond university)	5:5:1	5:5:1	1.00	4:3:2	4:3:2	1.00
T2 age (months)[a]	61.89 (10.99) 43.07–78.92	32.30 (8.43) 20.47–52.70	<0.001	59.13 (5.90) 47.01–67.68	30.80 (7.65) 20.01–46.49	<0.001

[a]Scores presented as mean (SD) and range. Group comparisons of child gender and parent education were analyzed using Fisher's exact test, while T2 child word types and T2 age were analyzed using t-tests.

Table 2. Descriptive and Inferential Statistics on Parental Input Features

	English speaking		French speaking					
	ASD (n = 11) M (SD) range	TYP (n = 11) M (SD) range	ASD (n = 9) M (SD) range	TYP (n = 9) M (SD) range		F(1, 36)	P-values	ω^2
Word tokens	664.64 (222.29)	606.09 (220.99)	587.78 (185.91)	674 (180)	DG	0.05	0.83	0.00
	208–1059	259–1033	301–888	362–958	L	0.00	0.95	0.00
					DG*L	1.24	0.27	0.01
Word types	142.64 (29.80)	146.46 (39.37)	150 (32.16)	168.11 (33.64)	DG	1.03	0.32	0.00
	68–178	89–216	105–196	114–226	L	1.80	0.19	0.02
					DG*L	0.44	0.51	0.00
Lexical diversity (D)	43.45 (6.78)	43.07 (10.54)	54.22 (11.07)	58.41 (6.93)	DG	0.44	0.51	0.01
	31.07–53.58	27.98–57.07	33.90–65.61	50.66–70.01	L	20.71	0.00***	0.34
					DG*L	0.63	0.43	0.00
MLU	5.06 (.92)	5.40 (.81)	5.14 (.96)	5.66 (.74)	DG	2.44	0.13	0.04
	3.94–6.80	4.04–6.12	3.04–6.03	4.49–6.55	L	0.10	0.75	0.00
					DG*L	0.40	0.53	0.00
Number of Utterances	143.82 (58.62)	112.36 (37.43)	123.56 (25.41)	138 (31.20)	DG	0.40	0.53	0.00
	47–259	47–169	84–171	98–177	L	0.05	0.83	0.00
					DG*L	3.11	0.09	0.05

***P < .001.
ASD, autism spectrum disorder; TYP, typical development; DG, diagnostic group; L, language.

distributions, homogeneity of variances, and independence of observations. Effect sizes are reported as ω^2 where 0.01, 0.06. and 0.14 represent small, moderate, and large effects, respectively [Cohen, 1988]. An adjusted alpha level of 0.01 (0.05/5) was used for the following analyses. Details of descriptive and inferential statistics are given in Table 2.

No significant main effects of diagnostic group were seen for any of the five input features (Ps > 0.13), and all effect sizes were small (ω^2s < 0.04). There were no main effects of language for word tokens, types, MLU, or number of utterances (Ps > 0.19, ω^2s < 0.02). There was a significant main effect of language for D with a large effect size, $F(1, 36) = 20.71$, $P < 0.001$, $\omega^2 = 0.34$. This effect is due to less lexically diverse input provided by EN mothers (M = 43.30, SD = 8.65) vs. FR mothers (M = 56.30, SD = 9.21), which may reflect an adaptation to child language level, as children in the EN sample used fewer word types on average (M = 53.70, SD = 38.10) than in the FR sample (M = 60.60, SD = 32.40). Finally, no significant interactions between diagnostic group and language were seen for any of the five input features and all exhibited small effect sizes (Ps > 0.09, ω^2s < 0.05).

Relationships Between Input and Later Child Vocabulary

Analyses. A hierarchical regression model was conducted to evaluate the relationship between input features and children's later vocabulary in each diagnostic group, including all dyads for whom we had T3 outcome data (ASD n = 19; TYP n = 44). Our dependent variable was children's T3 percentage of words produced (henceforth, T3 vocabulary). Demographic data for this sample can be seen in Table 3. Assumptions of linearity, homoscedasticity, and normally distributed errors were satisfied by visual inspection. Multicollinearity was satisfied with variance inflation factors <10 [i.e. 1.04–1.62; Field, Miles, & Field, 2012]. One outlier was kept in the model because it did not significantly influence the model as measured by Cook's D < 1 [Cook & Weisberg, 1982]. Significance of models and predictors were measured against an alpha level of 0.05.

Table 3. Child and Parent Demographic Data for Regression Sample *n* = 63

	ASD (n = 19) M (SD) range	TYP (n = 44) M (SD) range
Child		
Sex (M : F)	14:5	23:21
T2 child word types	54.21 (40.14)	57.64 (31.49)
	0–125	0–106
T2 age (months)	60.74 (9.19)	30.96 (7.35)
	43.07–78.92	18.69–52.70
T3 age (months)	67.39 (9.10)	37.40 (7.36)
	50.07–85.17	24.90–58.40
T3 % words spoken on MCDI	81.50 (24.10)	88.90 (18.70)
	27–100	31.90–100
Mother		
Maternal education (below university: university degree: beyond university)	8:8:3	10:18:16
T2 input MLU	5.07 (.93)	5.35 (.89)
	3.04–6.80	3.33–6.97

Data are collapsed across languages. EN ASD = 11; FR ASD = 8; EN TYP = 25 and FR TYP = 19.

Model building. Predictors were included in the order of their theoretical importance based on previous literature [Field et al., 2012]. This resulted in child T2 language (i.e. word types) selected for step 1 [Hoff & Naigles, 2002; Hurtado et al., 2008], followed by input features in step 2. To assess which input variables to include in our model, we conducted partial-order correlations with our regression sample between each input feature and child T3 vocabulary, while controlling for child T2 word types. Input features with significant partial correlations were included in the model. Partial correlations revealed that input MLU ($r(42) = 0.41$, $P < 0.01$) was the only input feature significantly correlated with child T3 spoken vocabulary when child language was controlled for; therefore, input MLU was included in step 2. Zero-order and partial correlations are shown in Table 4 for both the regression sample and each diagnostic group. To evaluate whether the magnitude of the relationship between input MLU and later language varies by diagnostic group, we included an interaction term between diagnostic group and input MLU. However, before the interaction term all main effects must be included, thus step 3 included the categorical predictor of diagnostic group (dummy coded), which was then followed by the interaction between diagnostic group and input MLU in step 4. This interaction can be interpreted as either (a) how the relationship between input MLU and child T3 vocabulary varies by diagnostic group, or (b) how the relationship between diagnostic group and child T3 vocabulary varies by MLU. For ease of interpretation, we adopt option (a). Following the method outlined by Aiken and West (1991) when including interactions in regression models, all continuous predictors were centered (i.e. predictors were entered as deviation scores from the overall mean) to reduce multicollinearity. Thus, the value of 0 represents the mean for continuous predictors. The interpretation of unstandardized betas remains the same, where a one unit increase in the predictor is associated with a change in the dependent variable by the value of the respective unstandardized beta.

Given the differences in chronological age between diagnostic groups and languages spoken, the final model was also examined with both of these predictors included. Neither chronological age nor language significantly contributed to the final model, and all results remained the same after including these predictors. Therefore, to increase power, these factors were not included in the final model.

Model results. As seen in Table 5, the final model in step 4 significantly explained 52% of the total variance in child T3 vocabulary, $F(4, 58) = 15.81$, $P < 0.001$. Child T2 word types and input MLU positively and significantly contributed 43% and 8%, respectively, to the variation in children's later vocabulary. Diagnostic group was not significant in our model, which reveals that after accounting for child language (i.e. word types), there was no additional variance in children's later vocabulary that was attributable to a diagnosis of ASD. Finally, the interaction between diagnostic group and input MLU was not significant. The combination of our findings of a significant predictor of MLU, and a nonsignificant interaction reveals two critical insights: (a) input MLU does significantly contribute to later vocabulary for both ASD and TYP children, and (b) the relationship between MLU and children's later vocabulary does not significantly differ by diagnostic group; that is input MLU has a similar impact on vocabulary growth in ASD as it does in typical development. Figure 1 depicts the raw observations in our sample and the positive direction of the slopes of our model (ASD slope = 9.24, TYP slope = 5.85) calculated from a simple slopes analysis (Aiken & West, 1991). It demonstrates the similarly positive and linear relationship between input MLU and later child vocabulary for children with ASD and typical development.

Discussion

Our findings demonstrate that children with ASD are exposed to similar linguistic environments, via maternal input, when compared with typically developing children matched on expressive language ability. Crucially, linguistic input as measured by MLU positively predicts children's spoken vocabulary 6 months later, over and above their initial language level, for children with ASD as it does for typically developing children.

Table 4. Zero-Order/Partial-Order Correlations Between Parental Input Features and Children's Later Vocabulary

Input Feature	Entire Regression Sample (n = 63)	ASD (n = 19)	TYP (n = 44)
Word Token	0.06/0.02	−0.08/−0.07	0.10/0.04
Word Types	0.33**/0.15	0.33/0.07	0.30*/0.17
D	0.19/0.12	0.16/0.05	0.19/0.15
MLU	0.52***/0.38**	0.70***/0.50*	0.41**/0.33*
Number of Utterances	−0.28*/−0.20	−0.43#/−0.33	−0.18/−0.12

#$P < .06$; *$P < .05$; **$P < .01$; ***$P < .001$.

Table 5. Hierarchical Regression of Parental Input and Children's Later Vocabulary

Predictor	ß	B	SE(B)	95% CI of B	R^2	ΔR^2
Step 1					0.43***	0.43***
Intercept		86.65***	1.97	[82.70–90.60]		
Child T2 types	0.65	0.40***	0.06	[.28–.51]		
Step 2					0.51***	0.08**
Intercept		86.65***	1.85	[82.96–90.35]		
Child T2 types	0.53	0.32***	0.06	[.21–.44]		
Input MLU	0.31	7.07**	2.26	[2.55–11.59]		
Step 3					0.52***	0.01
Intercept		86.65***	1.84	[82.96–90.34]		
Child T2 types	0.53	0.32***	0.06	[.21–.44]		
Input MLU	0.29	6.74**	2.28	[2.18–11.30]		
Diagnostic group	−0.10	−4.31	4.06	[-12.44–3.82]		
Step 4					0.52***	0.00
Intercept		88.04***	2.23	[83.58–92.50]		
Child T2 types	0.51	0.31***	0.06	[.19–.43]		
Input MLU	0.26	5.85*	2.60	[.65–11.04]		
Diagnostic group	−0.09	−3.93	4.11	[−12.16–4.30]		
Diagnostic group *MLU	0.08	3.39	4.68	[−5.97–12.75]		

$*P < .05$; $**P < .01$; $***P < .001$.

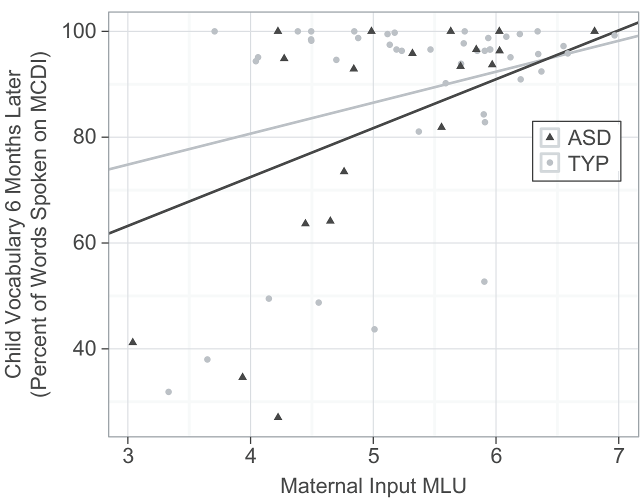

Figure 1. Depicts the raw data observed for each dyad: maternal input mean length of utterances (MLU) and the respective child's T3 % of words spoken on the MacArthur-Bates Communicative Development Inventories (MCDI). Regression lines depict the simple slopes for each diagnostic group calculated from the final regression model (step 4), which holds all other predictors at their mean value. This figure demonstrates a positive linear relationship between input MLU and children's T3 productive vocabulary, which did not differ significantly between autism spectrum disorder (ASD) and typical development (TYP) groups.

Mothers of children with ASD did not significantly differ from mothers of typically developing children on the five input features examined (i.e. word tokens and types, D, MLU, and number of utterances). This replicates previous findings for English-speaking families with children with ASD [i.e. word tokens, Warren et al., 2010; word types, Swensen, 2007; and MLU, Wolchik, 1983], and adds a similar finding for the previously unstudied feature of lexical diversity (using D). We offer two interpretations of these findings. First, it is possible that the lack of significant differences is due to methodological issues such as a small sample size. However, given the replication of previous studies and small effect sizes found for our group comparisons, we suggest that the lack of significant differences indicates that, in fact, mothers of children with ASD provide comparable linguistic environments to mothers of typically developing children when their children have comparable expressive language skills. These findings are novel in examining a range of linguistic input features in the same sample, as well as finding similar patterns in both English and previously unstudied French-speaking families. In prior studies, nonlinguistic aspects of parental input such as use of gesture, as well as coordination of verbal behavior (i.e. verbalizations that refer to the child's focus of attention), have also been shown to be similar across groups when children are matched on language ability [Bani Hani, Gonzalez-Barrero, & Nadig, 2012; Siller & Sigman, 2002]. Importantly, this body of findings demonstrates that the parental input provided to children with ASD constitutes a learning environment that is as linguistically and interactively rich as that provided to typically developing children. When investigating parental input, we matched children on expressive language, as the nature of parental input varies according to a child's language abilities [e.g. Snow, 1972]. Given their characteristic language delays, the similarly rich input we observed parents producing for their children occurred at a significantly later point in development for children with ASD (on average almost 2 and a half years later in our matched sample) than for typically developing children.

Our finding that input positively predicted child vocabulary approximately 6 months later replicates work demonstrating strong relationships between input and later child vocabulary in typical development [Hoff & Naigles, 2002; Rowe, 2012], and extends the previous reports on ASD [Swensen, 2007; Warren et al., 2010] by directly comparing this relationship across groups in a single regression model. Figure 1 demonstrates a robust positive and linear relationship between input and later vocabulary in typical development, as well as in ASD, despite many children performing near ceiling on our outcome measure of expressive vocabulary (see p. 11). We are limited in the ability to interpret the strength of the slope given the scores near ceiling; however, we can state that the groups did not differ reliably from each other with respect to the mother input–child language outcome relationship. Nevertheless, the combination of our findings that (a) input MLU significantly accounted for 8% of the variance in later child vocabulary while controlling for initial child language, and (b) a lack of a significant interaction between input MLU and diagnostic group leads us to conclude that input MLU plays a similar and important role in later vocabularies of children with ASD and typically developing children.

Given that children with ASD can benefit from linguistic input, what should be done to optimize their language development? First, parents of children with ASD should be encouraged, as parents generally are, to engage their children in rich language interactions [e.g. Rich, 2014]. In the context of intervention, strategies such as expansions of child language (e.g. child says "car" and parent says, "That's a bright blue car") are supported by our findings and the results of intervention studies with children with ASD [e.g. Hancock & Kaiser, 2002; Scherer & Olswang, 1989]. Conversely, intervention approaches that promote the use of simplified language (e.g. telegraphic speech or shorter MLUs) are not supported by our findings and should be applied with caution. If simplified language is deemed necessary for a child's limited cognitive and/or language abilities, MLU should then be expanded as a child's comprehension abilities develop [e.g. Sussman, 1999].

When considering input factors that contribute to language development in ASD, our focus here was on the relatively understudied linguistic input produced by parents, or what they say. Yet, it is clear that other factors are important as well, namely how parents speak to their children. For example, aspects of social-pragmatic input such as how often parents question, comment, or expand on their child's language also impact language development. In particular, social-pragmatic input that is synchronous with the child's focus of attention significantly and positively predicts language in toddlers with ASD [Haebig, McDuffie, & Wesimer, 2013; McDuffie & Yoder, 2010; Perryman et al., 2013] and even up to 16 years later [Siller & Sigman, 2008]. The current findings add to our understanding of the learning environment available to children with ASD and how they make use of it for language development. Future work should examine the synchrony of linguistic input with social-pragmatic input and child attention, and identify their respective relationships with later child language to develop a model of environmental contributions to language development in ASD.

Limitations

There was a limited range of scores on our language outcome measure, the MCDI Infant Form—Words and Gestures (see p. 11). Future work should explore parental input–language outcome relationships using additional age groups and language measures. Additionally, to limit the number of predictors in our regression models, we were unable to account for other predictors known to influence later child language such as SES [Hoff, 2003].

Conclusion

We examined the content of maternal language to children with ASD, and how this linguistic input influences later child language. Our findings reveal that children with ASD are, in fact, exposed to an environment as rich in lexical information as their typically developing counterparts of comparable language level with respect to number of word tokens and types, lexical diversity, MLU, and number of utterances. Moreover, a hierarchical regression model showed that input MLU significantly predicted later child vocabulary over and above initial child language, indicating that children with ASD are able to utilize maternal input for their vocabulary development. The present study provides important information on environmental factors implicated in language development in ASD.

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