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The relations between maternal language input and language development for children with Williams syndrome.

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The Relations Between Maternal Language Input and Language Development for Children with Williams Syndrome

By

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Abstract

For typically developing (TD) children, maternal language input (MLI) is an important contributor to early language development. Until now, possible relations between MLI and language development for children with Williams syndrome (WS), a genetic neurodevelopmental disorder associated with language delay and intellectual disability, have not been addressed. The aim of the present study was two-fold: to examine concurrent relations between MLI and child language abilities at 24 months and to determine if individual differences in MLI and children's lexical and cognitive abilities at 24 months make significant unique contributions to the variance in child language abilities at 48 months for children with WS. Participants included 34 mother-child dyads. Lexical diversity (number of different words; NDW) and grammatical complexity (mean length of utterance in morphemes; MLUm) measures of MLI were assessed during a 30-minute naturalistic play session at 24 months of age. For the child, standardized assessments of language and cognitive ability, as well as lexical (NDW) and grammatical (MLUm) ability measures from the play session were collected at 24 and 48 months of age. Mothers also completed a parent-report measure of child lexical and grammatical abilities at both ages. Concurrent relations between MLI and child measures of language and cognitive development were significant for maternal NDW but not for maternal MLUm. Regression analyses indicated that maternal NDW contributed significant unique variance to child receptive language at 48 months, even after taking into account child 24-month expressive vocabulary and 24-month nonverbal reasoning ability. Maternal MLUm accounted for significant unique variance in child receptive language and child MLUm at 48 months, even after accounting for the contributions of child 24-month expressive vocabulary and nonverbal reasoning ability. Implications of these findings are discussed.

Introduction

Williams syndrome (WS) is a neurodevelopmental disorder that stems from the hemizygous microdeletion of approximately 26 genes on chromosome 7q11.23 (Mervis et al., 2000; Osborne & Mervis, 2007). WS is associated with mild to moderate cognitive disability (Mervis & Becerra, 2007; Mervis & Robinson, 2000). Additionally, individuals with WS exhibit weakness in visuospatial construction and demonstrate relative strengths in verbal short-term memory and concrete language (Mervis et al., 2000; Mervis & John, 2008; Mervis & Robinson 2000). Despite the relative strength in concrete language, the acquisition of language is delayed in most children with WS (Mervis & Becerra, 2007; Mervis & Robinson, 2000). Since most children with WS experience delayed language development, it is important to investigate potential factors that could benefit early language development, such as maternal language input (MLI).

MLI, the language the mother uses when talking with her child, is associated with the language acquisition of both typically developing (TD) children (e.g., Hoff-Ginsberg, 1986) and children with intellectual and developmental disorders (IDD) such as autism spectrum disorder (ASD; e.g., Bang & Nadig, 2015) and Down syndrome (DS; e.g., Zampini et al., 2012). However, the relations between MLI and child language development have not been studied for children with WS. Therefore, the purpose of this study was to explore potential connections between MLI and language development in young children with WS.

Early Lexical Abilities in Children with WS

Expressive vocabulary (EV) is a measure of lexical development and has been used to investigate language development in young children with WS (e.g., Becerra & Mervis, 2019; Mervis & Becerra, 2007). EV consists of the words spontaneously produced by the child. EV is frequently measured by the Vocabulary Checklist from the MacArthur-Bates Communicative Development Inventories (CDI; Fenson, et al., 2007), a parental report measure of language development. Mervis and Becerra (2007) reported that for most children with WS, age of acquisition of an EV size of 10-, 50-, and 100- words was below the 5th percentile for the CDI norms. For reference, the median acquisition age of a 100- word EV is 18 months for TD children and 28 months for children with WS (Mervis & Becerra, 2007). In addition, Becerra and Mervis (2019) reported that 78.7% of 47 24-month-olds with WS scored below the 5th percentile of the CDI norms. Therefore, early lexical development is delayed in most children with WS.

Maternal Language Input and Language Development

Typically Developing Children

Within the TD population, various aspects of MLI have been shown to be related to later child language development (e.g., Hoff-Ginsberg, 1986; Mimeau et al., 2019). Aspects of MLI such as lexical diversity, grammatical complexity, and mean length of utterance in morphemes (MLUm) have been studied to determine relations to language development in TD children. Hoff-Ginsberg (1986) conducted a study that analyzed the relation of these and other variables of MLI and how they relate to language abilities in TD 24-month-olds and found a positive relation between maternal syntactic complexity and child syntactic development 4 to 6 months later.

The pioneering work of Hoff-Ginsberg paved the way for additional studies of the relations between MLI and early child language development. Recently, Mimeau et al. (2019) studied language input as defined by quantity (measured by number of utterances) and quality (measured by sensitivity to the child) provided by mothers of TD twins at age 5 months and its relation to child language at 18, 30, and 62 months of age. The findings suggest that increased quantity of maternal speech positively predicted child vocabulary comprehension (measured by the French-Canadian adaptation of the Peabody Picture and Vocabulary Test; PPVT; Dunn & Theriault-Whalen, 1993) and production (measured by an adaptation of the French-Canadian PPVT for assessing EV) at 62 months. Increased maternal sensitivity positively predicted child comprehension and production as assessed by parental report at 30 months and comprehension as assessed by the PPVT at 62 months.

Vernon-Feagans et al. (2019) followed TD children from 6 to 36 months of age to compare average MLI across groups of mothers of different race and educational attainment status. Child measures were defined using the Adaptive Language Inventory Scale teacher questionnaire (Feagans & Farran, 1982), PPVT-4 (Dunn & Dunn, 2007), and the Woodcock-Johnson Picture Vocabulary Test (Woodcock, McGrew, & Mather, 2001). These assessments measure narrative, receptive, and expressive language, respectively. MLI was determined from a completed transcript from a mother-child wordless picture book task by average quantity (measured by number of different words and number of conversational turns) and complexity (measured by MLU, number of complex conjunctions, and number of Wh- questions) of four sessions. MLI quantity and complexity did not differ significantly between African American and non-African American mothers. However, mothers with education above a high school degree provided significantly more input as measured by all MLI variables than other mothers. Additionally, their children’s language was more advanced on all child language measures. Significant relations were found between maternal number of different words, MLU, and all child language measures.

Children with Intellectual and Developmental Disabilities

While many studies have been completed regarding the relations between MLI and child language development, most of the literature focuses on TD children. Some of the studies addressing the relation between MLI and language development of children with IDD include children with ASD (Bang & Nadig, 2015; Naigles, 2013; Sandbank & Yoder, 2016) and DS (Lorang et al., 2020; Zampini et al., 2012).

Naigles (2013) performed a longitudinal study to investigate lexical and grammatical MLI in relation to child language four months later (measured by MLU, CDI Vocabulary Checklist, and the Mullen Scales of Early Learning; Mullen, 1995). This study included 10 children with ASD (mean chronological age = 33 months, *SD* = 4.06) and 12 TD children (descriptive statistics and group matching not provided). The lexical and grammatical MLI analyses identified a significant positive correlation ($p < .01$) between maternal noun frequency and child lexical diversity (as measured by CDI-EV) four months and eight months later for the children with ASD, which is consistent with the relation that was observed for the TD children in the study, as well as previous literature on TD children.

Bang and Nadig (2015) identified a significant positive relation between maternal MLU and child EV 6 months later in 19 children with ASD (50 – 85 months of age) and 44 TD children (25 – 58 months of age) matched on EV size (as measured by the CDI Words and Gestures form [Fenson et al., 2007] or the corresponding French version [Trudeau et al., 1999]). Findings from a different longitudinal study (Fusaroli et al., 2019) indicated that maternal MLU was significantly related to child MLU, word types, and word tokens four months later for both children with ASD ($N = 32$, mean chronological age = 32.76 months) and TD children ($N = 35$, mean chronological age = 20.27 months) matched for child language ability as measured by the Mullen Scales of Early Learning (MESL; Mullen, 1995) Expressive Language raw score.

Sandbank and Yoder (2016) presented a correlational meta-analysis in which parental grammatical complexity and child syntax ability (measured by respective MLU values) were assessed across children with various IDD, including ASD and DS, using a random-effects model to determine mean effect size (magnitude of the relation between the two variables). Four studies of children with ASD and their parents were included with three of the four involving the mother as the communicative partner. Five studies of children with DS and their mothers were included as well. Further random-effects subgroup analyses were performed to compare parental grammatical complexity and grammatical ability of children with various IDD across groups. The only significant positive relation was between complex parental grammar and grammatical ability in children with ASD (r = .51, 95% CI [.18 – .84]). Of the studies on children with ASD, all four had positive effect size estimates, with two being significantly positive. The significant positive relation between parental grammatical complexity and grammar ability in children with ASD is consistent with previous findings for TD children.

Venuti et al. (2012) studied the effects of MLI on children's language development in three different groups of children: TD (N = 20, mean chronological age = 24.70 months), ASD (N = 20, mean chronological age = 52.95 months), and DS (N = 20, mean chronological age = 41.15 months). Group matching of the children was completed using developmental age, which had a mean value of 24.77 months (SD = 8.47) across all groups. This study compared functional language input (defined as the intention of language as measured by affect-salient speech, information-salient speech, and child name) of mothers with TD children to mothers of children with ASD or DS. The findings indicate that input from mothers of children with ASD did not significantly differ from other mothers except for the more frequent use of the child's name when compared to mothers of TD children and children with DS. Additionally, input from mothers of children with DS did not significantly differ from other mothers except for significant use of affect salient speech when compared to MLI of TD children. Although the MLI across groups was similar, the effects on children's language differed across groups. No significant relations were identified between MLI and child language for the children with ASD or DS. Significant positive relations were found between maternal verbal descriptions and maternal environmental references (two kinds of information-salient speech) and child MLU for TD children.

However, it is important to note that while there were consistencies across maternal language there were also differences, such as mothers of children with DS using "less complex and sophisticated conversational patterns" when the groups are matched on chronological age (Venuti et al., 2012, p. 2). Zampini et al. (2012) compared maternal language input between a group of mothers of children with DS and two groups of mothers with TD children, one matched for chronological age and the other matched for EV (measured by the Italian version of the CDI; Caselli & Casadio, 1995). The analyses indicated that the complexity (defined as number of verbs per utterance) of the language of mothers of children with DS was lower than that of mothers of TD children of the same chronological age. However, the input of mothers of children with DS was more complex than that of mothers of TD children matched for lexical ability (and therefore younger in chronological age; Zampini et al., 2012).

In a recent study, Lorang et al. (2020) identified a similar relation for mothers of children with DS. On average, the mothers of the children with DS (*N* = 22, mean chronological age = 42.8 months, range = 22 – 63 months) presented a simplified pattern of input, characterized by decreased grammatical complexity and lexical diversity when compared to mothers of TD children (*N* = 22, mean chronological age = 44 months, range = 26 – 63 months) matched for chronological age. Lorang et al. found that maternal MLU was not significantly related to child language ability (as measured by MLUm, number of different words produced [NDW], and raw scores on the MSEL Receptive Language and Expressive Language scales) for children with DS. In contrast, maternal NDW was significantly positively correlated with child receptive language ability (as measured by MSEL Receptive Language raw score). These findings are different from the ones for the TD group, for which maternal MLUm was significantly correlated with child MLUm and MSEL Receptive Language and Expressive Language raw scores. Maternal NDW was not significantly related to any child language variables for the TD group.

In summary, various aspects of MLI have been found to relate to later child language abilities for TD children (Hoff-Ginsberg, 1986; Mimeau et al., 2019; Vernon-Feagans et al., 2019). Significant relations between MLI and early language development have been identified for children with ASD, such as maternal noun frequency relating to later child lexical diversity (Naigels, 2013) and maternal MLU relating to later child MLU (Bang & Nadig, 2015; Fusaroli et al., 2019; Sandbank & Yoder, 2016). These findings regarding early language development in children with ASD are consistent with the literature on TD children. For children with DS, maternal NDW has been found to relate to receptive language abilities which is different than trends seen in TD children (Lorang et al., 2020). Other typical relations between MLI and TD child language development are not reflected in the relations for children with DS. The compilation of these studies highlights the importance of additional research on MLI and its relations with child language abilities in children with various IDD.

The Present Study

The present study addresses the need to study the relation between MLI and child language development in children with WS, a group of children with IDD for which this relation has not been addressed. This study will consider two aspects of MLI directed to 24-month-olds with WS: MLUm and NDW and will determine how they relate to the child's concurrent language abilities and to the child's language abilities at age 48 months. Two research questions will be addressed:

1. What are the relations between maternal language input to 24-month-olds with WS and the child's concurrent language abilities?

2. How does maternal language input to 24-month-olds with WS relate to child language abilities at 48 months?

Methods

Participants

The final sample included 34 children (16 females, 18 males) with genetically confirmed classic-length deletions of the WS region and their mothers. All participants were native speakers of English and produced at least 20 spontaneous intelligible utterances during their 48-month play session. Descriptive statistics for chronological age (CA) at the 24-month and 48-month data points are presented in Table 1. The 34 children came from 19 different states and the District of Columbia, with all four United States census regions represented (12% East, 60% South, 20% Midwest, 9% West). The racial/ethnic distribution of the sample was 88% White non-Hispanic, 6% White Hispanic, and 6% biracial non-Hispanic. The mothers of 79% of the participants had earned at least a bachelor's degree. Two additional children with classic WS deletions (1 female, 1 male) were excluded from the final sample because they did not produce at least 20 intelligible spontaneous utterances during the 48-month play session. Data collection began in December 2002 and ended in September 2020.

Table 1

Descriptive Statistics for Participants' Chronological Ages at the 24- and 48-month Sessions

Chronological Age (Months)	Mean	SD	Range
24	24.46	0.27	24.08 – 24.94
48	48.47	0.27	48.07 – 48.97

Note: *N* = 34, *SD*: standard deviation**.**

Measures

Naturalistic Mother-child Play Sessions

Mother-child dyads participated in 30-minute naturalistic play sessions when the children were 24 and 48 months old. Play session video recordings were transcribed and analyzed using Systematic Analysis of Language Transcripts (SALT) software (Miller et al., 2019). The following measures were determined from the play session transcripts:

Child Language. The child's language abilities that were measured from the play session include grammatical ability as determined by MLUm and lexical ability as determined by NDW. These data were collected from the 24- and 48-month play sessions.

Maternal Language Input (MLI). Measures of MLI included grammatical complexity as determined by maternal MLUm and lexical diversity as determined by maternal NDW. MLI data were collected from the 24-month play session.

MacArthur-Bates Communicative Development Inventories: Words and Sentences (CDI-W&S, Fenson et al., 2007)

The CDI-W&S is a parental report measure of language development normed for children between the ages of 16 and 30 months. It is also widely used to measure language abilities of children older than 30 months who have developmental delay. This study uses the CDI-W&S Vocabulary Checklist (a 680-word list in which the parent reports the words that their child says and/or signs spontaneously) to determine EV size as a measure of the child's lexical ability. CDI-EV was determined at ages 24 and 48 months. The CDI-W&S Sentence Complexity scale (CDI-SC) was used as a measure of child grammatical ability at age 48 months. The CDI-SC is composed of 37 pairs of sentences of various grammatical complexity in which parents report which sentence in each pair sounds more like the way their child communicates. The child's SC is the number of sentence pairs for which the parent reported the child produced the more complex version.

Mullen Scales of Early Learning (MSEL; Mullen, 1995)

Child intellectual abilities were measured by the MSEL. The MSEL is normed for infants, toddlers, and preschoolers ages 1 to 68 months and consists of four subscales: Visual Reception (VR, measuring primarily nonverbal reasoning), Receptive Language (RL), Expressive Language (EL), and Fine Motor (measuring primarily visuospatial construction). The mean T-score for each subscale is 50 (*SD* = 10) for the general population. The Early Learning Composite (ELC) is a measure of overall intellectual ability determined by performance on all four scales. The mean ELC for the general population is 100 (*SD* = 15). The MSEL was administered to all participants at ages 24 and 48 months.

Procedures

The participants included in this study are part of an ongoing research study led by Dr. Carolyn B. Mervis. The 24- and 48-month assessments took place at the Neurodevelopmental Sciences Lab at the University of Louisville. All 34 participants completed the MSEL and a play session with their mother at both age 24 months and age 48 months. The MSEL was administered and scored according to the standardized procedures. In addition, mothers completed the CDI-W&S at both sessions. The CDI-W&S was administered to the parent by a trained researcher. All play sessions were initially transcribed by a trained transcriber using

SALT. Once completed, the original transcriber partnered with a second transcriber to review the transcript and reach consensus on the utterances produced by the mother and the child. A final review of the transcript was performed by an third transcriber to verify all coding and spoken language before using SALT data for analyses.

Statistical Analyses

Data for this study were analyzed using IBM SPSS v. 27. The distributions for CDI-EV, CDI-SC, MSEL VR T-score, child NDW, and child MLUm were not normal. Therefore Spearman correlations were used, rather than Pearson correlations, to describe concurrent relations between measures of MLI and child language abilities at 24 months. For the correlation analyses, α was set at $p = 0.01$, two-tailed.

To determine relations between early MLI and later child lexical and grammatical ability, a series of multiple regression analyses was performed. For the multiple regression analyses considering the effect of maternal lexical diversity on later child language, the predictors included maternal lexical diversity (mNDW), child CDI-EV at 24 months, and MSEL VR T-score at 24 months. Separate multiple regressions were performed for the two measures of child lexical ability at age 48 months: cNDW and CDI-EV, and the two measures of overall language ability at 48 months: MSEL RL T-score and EL T-score. For the multiple regression analyses considering the effect of maternal grammatical complexity on later child language, the predictors included maternal grammatical complexity (mMLUm), child CDI-EV at 24 months, and MSEL VR T-score at 24 months. Separate multiple regressions were performed for the two measures of child grammatical ability at 48 months: cMLUm and CDI-SC, and the two measures of overall language ability at 48 months: MSEL RL T-score and EL T-score.

Results

Concurrent Correlations of Maternal Language Input and Child Language Abilities

Descriptive statistics for child language abilities at age 24 months are shown in Table 2. As indicated in the table, there was considerable variability on all measures except for cMLUm. The median CDI-EV was below the 5th percentile on the CDI norms for 24-month-olds (Fenson et al., 2007), indicating considerable language delay for the sample as a whole. At the same time, the median CDI-EV was at the 50th percentile on the provisional norms for 24-month-olds with WS (Mervis et al., 2019), indicating that the children in the present sample were representative of 24-month-olds with WS overall.

Table 2

Descriptive Statistics for Children's Language and Intellectual Abilities at Age 24 Months

Measure	Mean	Median	SD	IQR	Range
CDI-EV	40.71	23.50	43.23	9.00 – 70.75	0 – 176
cMLUm	0.88	1.00	0.42	1.00 – 1.10	0 – 1.33
cNDW	10.06	5.50	13.38	1.75 – 17.26	0 – 58
MSEL RL	34.23	32.00	12.48	24.00 – 47.75	20 – 56
MSEL EL	34.74	36.00	8.68	28.00 – 41.75	20 – 51
MSEL VR	33.53	34.00	10.78	23.00 – 43.00	20 – 53
MSEL ELC	69.65	68.00	14.33	55.75 – 82.25	49 – 96

Note. N = 34, SD: standard deviation, IQR: interquartile range, CDI-EV: *MacArthur-Bates Communicative Development Inventories: Words and Sentences* – Expressive vocabulary, cMLUm: child mean length of utterance in morphemes, cNDW: child number of different words, MSEL: *Mullen Scales of Early Learning*, RL: Receptive Language, EL: Expressive Language, VR: Visual Reception, ELC: Early Learning Composite.

Descriptive statistics for maternal language input are provided in Table 3. As indicated in the table, there was considerable variability across mothers in both the lexical diversity and the grammatical complexity of the language input they provided to their child**.**

Table 3

Descriptive Statistics for Maternal Language Input during 24-month Play Session

Measure	Mean	Median	SD	IQR	Range
mNDW	229.09	232.50	61.13	184.25 – 281.75	118 – 338
mMLUm	3.08	3.13	0.50	2.68 – 3.52	2.24 – 4.14

Note. $N = 34$, MLI: maternal language input, SD: standard deviation, IQR: interquartile range, mNDW: maternal number of different words, mMLUm: maternal mean length of utterance in morphemes.

To determine the concurrent correlations for MLI and child language abilities, a series of Spearman correlations was performed (Table 4). Significant concurrent correlations were found between maternal lexical diversity (mNDW) and all child measures of language and intellectual abilities. However, no significant concurrent correlations between maternal grammatical complexity (mMLUm) and child language and cognitive abilities were found.

Table 4

Spearman Concurrent Correlations between Maternal Language and Child Language Abilities at 24 Months of Age

MLI Variable	CDI-EV	cNDW	MSEL RL	MSEL EL	MSEL ELC
mNDW	.50*	.64*	.49*	.45*	.57*
mMLUm	.29	.28	.41	.22	.39

Note. $N = 34$, MLI: Maternal Language Input, CDI-EV: *MacArthur-Bates Communicative Development Inventories: Words and Sentences* – Expressive Vocabulary, cNDW: child number of different words, MSEL: *Mullen Scales of Early Learning*, RL: Receptive Language, EL: Expressive Language; ELC: Early Learning Composite, mNDW: maternal number of different words, mMLUm: maternal mean length of utterance in morphemes, $^{*}p < .01$.

Contributions of Maternal Language Input to Child Language Abilities at Age 48 months

To determine the contributions of MLI when the child was 24 months old to child language abilities at 48 months of age, eight multiple regressions were completed: four addressing the effect of maternal lexical diversity on child lexical abilities and overall language and four addressing the effect of maternal grammatical complexity on child grammatical abilities and overall language. Descriptive statistics for the dependent variables in these analyses are presented in Table 5 and descriptive statistics for the predictors are shown in Table 6. Once again, there was considerable variability on all measures. Median CDI-EV was at the 50th percentile on the preliminary WS CDI norms (Mervis et al., 2019) and median CDI-SC was at the 61st percentile, indicating that the present sample of children was representative of 48-month-olds with WS.

Table 5

Descriptive Statistics for Participant Measures at 48 Months of Age

Variable	Mean	Median	SD	IQR	Range
CDI-EV	459.00	483.00	159.70	344.50 – 579.75	65 – 679
cNDW	109.53	111.50	51.16	67.50 – 152.50	25 – 201
MSEL RL	32.97	26.00	12.12	20.00 – 21.00	20 – 55
MSEL EL	37.65	29.00	8.43	32.00 – 45.00	20 – 53
CDI-SC	18.82	20.00	13.90	5.50 – 20.00	0 – 37
cMLUm	2.50	2.64	0.74	1.09 – 3.04	1.00 – 4.00

Note. *N* = 34, *SD*: standard deviation, IQR: interquartile range, CDI-EV: *MacArthur-Bates Communicative Development Inventories: Words and Sentences* – Expressive Vocabulary, cNDW: child number of different words, MSEL: *Mullen Scales of Early Learning* RL: Receptive Language, EL: Expressive Language, CDI-SC: *MacArthur-Bates Communicative Development Inventories: Words and Sentences* – Sentence Complexity, cMLUm: child mean length of utterance in morphemes.

Table 6

Descriptive Statistics for Predictors at 24 Months of Age Included in the Multiple Regression Analyses

Predictors	Mean	Median	SD	IQR	Range
mNDW	229.09	232.50	61.13	184.25 – 281.75	118 – 338
mMLUm	3.08	3.13	0.50	2.68 – 3.52	2.24 – 4.14
MSEL VR	33.53	34.00	10.73	23.00 – 43.00	20 – 53
CDI-EV	40.71	23.50	43.23	9.00 – 70.75	0 – 176

Note. *N* = 34, SD: standard deviation, IQR: interquartile range, mNDW: maternal number of different words, mMLUm: mean length of utterance in morphemes, MSEL: *Mullen Scales of Early Learning*, VR: Visual Reception, CDI-EV: *MacArthur-Bates Communicative Development Inventories: Words and Sentences* – Expressive Vocabulary.

Spearman correlations between the variables included in all eight multiple regression analyses are presented in Table 7. Apart from several of the correlations involving mMLUm at 24 months, all correlations were statistically significant.

Table 7

Spearman Correlations between Variables Included in the Multiple Regression Analyses

Measure	2	3	4	5	6	7	8	9	10
1. CDI-EV at 24 months	.68*	.50*	.29	.74*	.74*	.69*	.69*	.77*	.81*
2. MSEL VR at 24 months		.51*	.32	.66*	.64*	.69*	.63*	.75*	.80*
3. mNDW at 24 months			.45*	.56*	.74*	.52*	.50*	.65*	.63*
4. mMLUm at 24 months				.43	.38	.33	.48*	.50*	.48*
5. CDI-EV at 48 months					.96*	.78*	.79*	.79*	.89*
6. CDI-SC at 48 months						.83*	.80*	.77*	.89*
7. cNDW at 48 months							.83*	.73*	.87*
8. cMLUm at 48 months								.78*	.87*
9. MSEL RL at 48 months									.84*
10. MSEL EL at 48 months									

Note. N = 34, CDI-EV: *MacArthur-Bates Communicative Development Inventories: Words and Sentences* – Expressive Vocabulary, MSEL: *Mullen Scales of Early Learning*, VR: Visual Reception, RL: Receptive Language, EL: Expressive Language, mNDW: maternal number of different words, mMLUm: mean length of utterance in morphemes, CDI-SC: *MacArthur-Bates Communicative Development Inventories: Words and Sentences* – Sentence Complexity, cMLUm: child mean length of utterance in morphemes, cNDW: child number of different words, *p<.001.

Contributions of Maternal Lexical Diversity

To determine the contributions of maternal lexical diversity (mNDW), child CDI-EV, and child nonverbal reasoning ability (MSEL-VR) at 24 months to child lexical ability (cNDW and CDI-EV) and overall language ability (MSEL RL and MSEL EL) at 48 months, four multiple regression analyses were conducted (Table 8). Each of the analyses accounted for a significant amount of variance in the dependent variable. For all four analyses, child nonverbal reasoning ability (MSEL VR T-score) at 24 months was a significant predictor. In addition, child EV size at 24 months as reported by the parent (CDI-EV) was a significant predictor of 48-month CDI-EV, MSEL RL, and MSEL EL and a marginally significant predictor of 48-month cNDW. Finally, mNDW at 24 months was a significant predictor of 48-month MSEL RL.

Table 8

Multiple Regression Analyses Predicting Child Lexical and Overall Language Abilities at 48 Months of Age

Variable	*B*	*t*	*p*-value	95% CI for *B*	Semi-partial *r*
cNDW at 48 months					
Constant	-2.13	-.08		[-59.11 – 54.85]	
mNDW at 24 months	0.10	0.82	.417	[-.15 – .35]	.10
MSEL VR at 24 months	2.22	3.13	.004	[.77 – 3.66]	.38
CDI-EV at 24 months	0.36	2.01	.053	[-.01 – .72]	.25
R^2 = .55, adjusted R^2 = .51, $F(3,30) = 12.33$, $p < .001$					
CDI-EV at 48 months					
Constant	86.96	1.07		[-79.67 – 253.58]	
mNDW at 24 months	0.53	1.48	.148	[-.20 – 1.26]	.17
MSEL VR at 24 months	5.93	2.89	.008	[1.71 – 10.15]	.33
CDI-EV at 24 months	1.28	2.49	.018	[.23 – 2.34]	.29
R^2 = .61, adjusted R^2 = .57, $F(3,30) = 15.48$, $p < .001$					
MSEL RL at 48 months					
Constant	4.70	1.00		[-5.02 – 14.41]	
mNDW at 24 months	0.04	2.09	.045	[.00 – .09]	.18
MSEL VR at 24 months	0.37	3.08	.004	[.13 – .62]	.27
CDI-EV at 24 months	0.14	4.78	<.001	[.08 – .21]	.42
R^2 = .77, adjusted R^2 = .75, $F(3,30) = 33.11$, $p < .001$					
MSEL EL at 48 months					
Constant	15.45	4.06		[7.67 – 23.23]	
mNDW at 24 months	0.03	1.62	.116	[-.01 – .06]	.16
MSEL VR at 24 months	0.41	4.27	<.001	[.22 – .61]	.43
CDI-EV at 24 months	0.05	2.26	.031	[.01 – .10]	.23
R^2 = .69, adjusted R^2 = .66, $F(3,30) = 22.53$, $p < .001$					

Note. N = 34, cNDW: child number of different words, mNDW: maternal number of different words, MSEL: *Mullen Scales of Early Learning*, VR: Visual Reception, EL: Expressive Language, RL: Receptive Language, CDI-EV: *MacArthur-Bates Communicative Development Inventories: Words and Sentences* – Expressive Vocabulary.

Contribution of Maternal Grammatical Complexity

To determine the contributions of maternal grammatical complexity (mMLUm) at the 24-month play session, child CDI-EV at 24 months, and child nonverbal reasoning ability at 24 months to child grammatical ability (play session cMLUm and CDI-SC) and overall language ability (MSEL RL and MSEL EL T-scores) at 48 months, four additional multiple regression analyses were conducted (Table 9). For all four analyses, child nonverbal reasoning (MSEL VR T-score) and EV as reported by the parent (CDI-EV) at 24 months were significant predictors. Additionally, mMLUm at 24 months was a significant predictor for cMLUm and MSEL RL at 48 months of age.

Table 9

Multiple Regression Analyses Predicting Child Grammatical and Overall Language Abilities at 48 Months of Age

Variable	*B*	*t*	*p*-value	95% CI for *B*	Semi-partial *r*
cMLUm at 48 months					
Constant	0.21	0.38		[-0.92 – 1.33]	
mMLUm at 24 months	0.40	2.21	.035	[.01 – .04]	.25
MSEL VR at 24 months	0.02	2.56	.016	[.00 – .01]	.29
CDI-EV at 24 months	0.01	2.86	.008	[.03 – .77]	.33
R^2 = .61, adjusted R^2 = .57, $F(3,30) = 15.85$, $p < .001$					
CDI-SC at 48 months					
Constant	-19.78	-1.79		[-42.29 – 2.74]	
mMLUm at 24 months	5.43	1.49	.146	[-2.01 – 12.86]	.18
MSEL VR at 24 months	0.52	2.80	.009	[.14 – .90]	.34
CDI-EV at 24 months	5.43	1.49	.022	[.02 – .21]	.29
R^2 = .56, adjusted R^2 = .52, $F(3,30) = 12.83$, $p < .001$					
MSEL RL at 48 months					
Constant	-3.08	-0.50		[-17.05 – 10.90]	
mMLUm at 24 months	5.51	2.44	.021	[.90 – 10.13]	.21
MSEL VR at 24 months	0.39	3.38	.002	[.15 – .62]	.29
CDI-EV at 24 months	0.15	5.23	<.001	[.09 – .21]	.45
R^2 = .78, adjusted R^2 = .76, $F(3,30) = 35.08$, $p < .001$					
MSEL EL at 48 months					
Constant	11.47	2.05		[.06 – 22.87]	
mMLUm at 24 months	3.10	1.68	.104	[-.67 – 6.86]	.17
MSEL VR at 24 months	0.43	4.54	<.001	[.23 – .62]	.46
CDI-EV at 24 months	0.06	2.52	.017	[.01 – .11]	.25
R^2 = .69, adjusted R^2 = .66, $F(3,30) = 22.73$, $p < .001$					

Note: $N = 34$, cMLUm: child mean length of utterances in morphemes, mMLUm: mean length of utterance in morphemes, MSEL: *Mullen Scales of Early Learning* VR: Visual Reception, EL: Expressive Language, RL: Receptive Language, CDI-EV: *MacArthur-Bates Communicative Development Inventories: Words and Sentences* – Expressive Vocabulary, CDI-SC: *MacArthur-Bates Communicative Development Inventories: Words and Sentences* – Sentence Complexity.

Discussion

Concurrent Correlations of Maternal Language Input and Language Abilities at Age 24 Months

The first goal of the present study was to determine concurrent relations between child language abilities and maternal lexical diversity and grammatical complexity at 24 months for children with WS. Significant concurrent correlations were found between maternal lexical diversity (mNDW) and all child language and cognitive measures at 24 months: EV as reported by the parent (CDI-EV), child lexical ability (cNDW), receptive language abilities (MSEL RL), expressive language abilities (MSEL EL), and overall cognitive abilities (MSEL ELC). However, no significant concurrent correlations between maternal grammatical complexity (mMLUm) and child language or cognitive abilities were found.

The findings regarding concurrent maternal lexical diversity and child language ability for children with WS were different from what has been found for TD 24-month-olds (Lorang et al, 2020). For these children, maternal lexical diversity was not significantly related to concurrent child language abilities. At the same time, maternal grammatical complexity was significantly related to concurrent child MLUm as well as MSEL receptive and expressive language raw scores. One similarity was identified between MLI and children with DS between the age range of 22 and 63 months (Lorang et al., 2020) and the children with WS in the present study, which was that greater maternal lexical diversity was significantly related to increased child receptive language abilities. I am not aware of concurrent correlational studies on maternal lexical diversity and child language abilities in children with ASD at 24 months of age.

The findings regarding concurrent relations between maternal grammatical complexity and child language abilities differed from those of previous research for TD children, as more complex maternal grammar is significantly related to grammatical ability as well as receptive and expressive language abilities in TD children (Lorang et al., 2020). However, a similarity between the present study and previous research for TD children is identified by the absence of relations between maternal syntactic complexity and child lexical diversity (Lorang et al., 2020). However, the nonsignificant relations between maternal grammatical complexity and the language and cognitive abilities of the child are similar to what is observed in children with DS (Lorang et al., 2020). I am not aware of concurrent correlational studies regarding the relation between maternal grammatical complexity and the language of children with ASD at 24 months of age.

Contributions of Maternal Language Input at 24 Months to Child Language Abilities at Age 48 Months

The second aim of the present study was to determine how maternal lexical diversity and grammatical complexity when their child was 24 months old related to child language abilities at 48 months for children with WS.

Maternal Lexical Diversity

While maternal lexical diversity presented significant concurrent correlations with child language ability at 24 months of age, the only 48-month child language measure for which maternal lexical diversity at 24 months was a significant predictor, after taking into account the contributions of child vocabulary size and nonverbal reasoning ability at 24 months, was child receptive language. This lack of significant relation is similar to findings reported in Bang and Nadig (2015), who found that parental lexical diversity was a nonsignificant predictor child EV 6 months later in TD children or children with ASD. However, the present study does not align with the identified significant positive relation between maternal lexical diversity and later child expressive language ability of TD children presented in Vernon-Feagans and colleagues (2019). The discrepancy between the findings of Bang and Nadig (2015) and Vernon-Feagans (2019) for TD children may be attributed to the time frame in which MLI was considered as the first study used MLI from 6 months prior whereas the second study averaged MLI from four sessions from 6 to 36 months of age. The present findings on 24-month-old children with WS are not consistent with the findings of Vernon-Feagans (2019) likely due to the inclusion of older ages of TD children in their sample. I am unaware of longitudinal studies on the relations between lexical MLI and later language abilities of children with DS.

Questions arise from the findings that lexical MLI at 24 months was not found to account for significant unique variance in language abilities at 48 months of age after accounting for the contributions of child EV and nonverbal reasoning ability at 24 months. A possible explanation is related to socio-communicative deficits in children with WS presented in Klein-Tasman et al. (2007) which details “that deficits in reciprocal social interaction found in the participants are contributing to poorer expressive and receptive language abilities in some children with WS, such that those children with WS who have more deficits in reciprocal social interaction are at a disadvantage in their language learning”. Therefore, indicating that the child’s lack of mirroring their communicative partner relates to lower speech production and comprehension in children with WS. Alternative explanations within Klein-Tasman et al. (2007) state that low child language abilities make relations difficult to analyze in social environments. While the present study indicates that maternal lexical diversity contributes to child receptive language, lexical diversity uniquely accounts for only 3% of the variance in receptive language abilities at 48 months of age. Further investigations into MLI and later child language abilities in children in

WS are needed to verify the relative magnitude of the effect of maternal lexical diversity on later child lexical ability.

Another significant finding from the lexical ability analyses was the identification of nonverbal reasoning (MSEL VR) as a significant predictor for all 48-month language variables. This result is unique when compared to studies of TD children and children with ASD as nonverbal reasoning raw scores at the first visit (mean TD child chronological age = 20.27 months, mean child with ASD chronological age = 32.98 months) were considered a nonsignificant predictor when analyzing child language development measured by amount of speech, vocabulary diversity, and grammatical ability two years later (Fusaroli et al., 2019). A finding consistent with Fusaroli and colleagues (2019) was the identification of the 24-month EV being a significant predictor of EV growth two years later.

Maternal Grammatical Complexity

Although no significant concurrent correlations were found between maternal grammatical complexity and child language abilities at 24 months, maternal grammatical complexity at child age 24 months (mMLUm) accounted for significant unique variance in both 48-month receptive language and grammatical abilities, even after considering child vocabulary size and nonverbal reasoning ability at 24 months. The identification of greater maternal syntactic complexity as a significant predictor of later child grammatical ability is consistent with findings for TD children and children with ASD as reported in Fusaroli et al. (2019). The nonsignificant relation between 24-month maternal syntactic complexity and later child EV ability is not consistent with previous findings for TD children and children with ASD (Bang & Nadig, 2015; Fusaroli et al., 2019). Again, a unique finding for children with WS is nonverbal reasoning as a significant predictor, as this result was not found for TD children or children with

ASD (Fusaroli et al., 2019). Another relation identified in the present study consistent with Fusaroli et al. (2019) was that child EV at 24 months was a significant predictor of later grammatical complexity (cMLUm). I am unaware of longitudinal studies on the relations between grammatical MLI and later language abilities of children with DS.

Potential Implications

In this study, I found multiple significant relations between MLI and child language ability. Regarding concurrent relations of language at 24 months of age, maternal lexical diversity (mNDW) was significantly correlated with all child language and cognitive measures. Maternal lexical diversity when the child was 24 months old significantly predicted child receptive language ability at 48 months of age, even after taking into account child vocabulary size at 24 months and child nonverbal reasoning ability at 24 months. The relations between maternal lexical diversity and child language ability suggest that children with WS may benefit from a language environment that includes greater vocabulary diversity. Additionally, significant relations were identified between maternal grammatical complexity (mMLUm) when the child was 24 months old and child grammatical and receptive language abilities at 48 months of age, even after taking into account child vocabulary size at 24 months and child nonverbal reasoning ability at 24 months. These findings indicate that children with WS may benefit from a language environment that includes a variety of grammatical constructions.

Limitations and Future Directions

Of the maternal participants, 79% had earned at least a bachelor’s degree. Maternal education is strongly related to both MLI and child language ability (Vernon-Feagans et al., 2019). Therefore, the relatively small proportion of mothers who had not earned at least a bachelor’s degree likely led to less variability in both MLI and in child language ability, which limited the power of the study to identify significant relations between MLI and child language development. All assessments were performed in the lab at age 24 and 48 months, with most families travelling from out of state to participate. Initially this sample was planned to include five more participants, for a total of 39, with their 48-month visits scheduled from March to September 2020. However due to COVID-19 these assessments had to be canceled. This 12.8% decrease from our expected sample size led to a significant reduction in statistical power.

An important limitation of using a correlation analysis is that significant correlations do not indicate causal relations between variables. Further research is needed to determine contributions of MLI to concurrent language abilities and later language abilities in young children with WS. To accurately compare MLI of mothers of children with WS to other groups, future comparisons of MLI across mothers of children with IDDs and TD children are needed. Future studies on MLI could provide a way to observe how children with IDD interact and learn from their communicative partners. Furthermore, investigations into how the unique social profile of children with WS may affect their ability to utilize input from their communicative partner would contribute to the understanding of what aspect(s) of language input is benefitting the child's language development.

The present study provides valuable insight into language development in young children with WS and can be beneficial in the contexts of early education and speech intervention. Education professionals may utilize knowledge on language input for tailoring individual intervention plans to increase exposure of certain linguistic components, as indicated by the child's language abilities. Speech intervention methodology may find value in assessing the overall language environment of the child and supplementing therapy sessions with input designed to increase exposure to the weaker aspects of the child's language. Additionally, parent intervention may be recommended to foster a language rich environment that fits the child's linguistic needs for further development.

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