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Research Article

Identifying Childhood Expressive Language Features That Best Predict Adult Language and Communication Outcome in Individuals With Autism Spectrum Disorder

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Purpose: Several studies have reported that "useful speech" at 5 years of age predicts outcomes in individuals with autism spectrum disorder (ASD), but this skill has been vaguely defined. This study investigates which specific aspects of expressive language in children with ASD best predict adult language and communication outcomes.
Method: Language samples from 29 children (ages 47–72 months) enrolled in a longitudinal project (e.g., Lord et al., 2006) were transcribed and coded for spoken language features. Hierarchical linear regression was used to compare the following childhood variables as predictors of adult language and communication outcomes: noun diversity, verb diversity, mean length of utterance, and proportion of utterances that were socially motivated.
Results: Childhood verb diversity was a value-added predictor of all four adult outcome measures (i.e., verbal IQ, Autism Diagnostic Observation Schedule Communication + Social Interaction Algorithm totals, Peabody Picture Vocabulary Test scores, and Vineland Adaptive Behavior Scales Communication Domain scores), while noun diversity and proportion of utterances that were socially motivated were not value-added predictors of any adult outcome measures. In a second set of regression analyses, mean length of utterance was substituted for verb diversity and was a value-added predictor of two out of four adult outcome measures (i.e., verbal IQ and Vineland Adaptive Behavior Scales Communication Domain scores). The pattern of findings for the other predictors remained the same as in the previous analyses.
Conclusion: These results have implications for our understanding of early language in ASD and for clinical decision making in early childhood.

Autism spectrum disorder (ASD) is characterized by social communication challenges and the presence of restricted, repetitive behaviors and/or interests (American Psychiatric Association, 2013). According to the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition* (American Psychiatric Association, 2013), structural language deficits (i.e., deficits in phonology, morphology, semantics, and/or syntax) are not considered diagnostic criteria for ASD. Nevertheless, great variability exists in language trajectories in ASD (Anderson et al., 2007) and across language domains, including expressive and receptive vocabulary, morphology, syntax, and higher level semantic knowledge (Kjelgaard & Tager-Flusberg, 2001; Tager-Flusberg & Joseph, 2003). Some individuals with ASD present with no structural language deficits, while around 30% remain minimally verbal into adulthood (Kjelgaard & Tager-Flusberg, 2001; Tager-Flusberg & Kasari, 2013), and many fall between those two extremes. Importantly, adult language ability in individuals with ASD is associated with a range of other outcomes, including social skills (Howlin et al., 2004, 2000), friendship ratings (Friedman et al., 2009; Howlin et al., 2000), adaptive and academic skills (Venter et al., 1992), and employment status/vocational independence (Friedman et al., 2009; Venter et al., 1992). Given the importance of language development for many outcomes, researchers have explored the development of language in

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ASD throughout childhood. Two sets of findings have emerged: the first pertaining to the timing of growth and the second pertaining to predictors of growth.

Timing of Language Growth

The period of early development is characterized by language delays and is a time of particular heterogeneity and change. Many individuals with autism exhibit delays or differences in prelinguistic skills, such as gestures, eye contact, imitation, and social affect (e.g., Zwaigenbaum et al., 2005). Delays in early receptive and expressive language skills—such as responding to one's name, word imitation, labeling, and vocabulary comprehension and production—may also be present (Charman et al., 2003). The most pronounced variability and change in language seem to exist during this early period, before approximately 6 years of age (e.g., DeMyer et al., 1973; Pickles et al., 2014; Rutter et al., 1967); after this age, there is evidence that individuals of all language profiles progress in parallel (Pickles et al., 2014). However, some individuals with ASD do demonstrate significant change in language skill (i.e., acquisition of speech) after ages 4–6 years (e.g., Pickett et al., 2009; Wodka et al., 2013).

Predictors of Language Growth

It is clear that early language milestones are formative in setting a course for language in later childhood and beyond. Thus, a long-standing body of research has explored what early linguistic capabilities predict later outcomes. A number of global skills have emerged as predictors. For instance, early childhood verbal and nonverbal IQ (VIQ and NVIQ, respectively) are both well-known predictors of language and communication outcome, as well as outcomes across other domains (e.g., autistic characteristics, social interaction, residential status, employment, independence) in individuals with ASD (e.g., Anderson et al., 2007; Billstedt et al., 2007; Eaves & Ho, 2008; Gillberg & Steffenburg, 1987; Howlin et al., 2004; Pickles et al., 2020; Rutter et al., 1967; Szatmari et al., 2003; Wodka et al., 2013). Omnibus measures of receptive and expressive language in early childhood also predict later childhood language and communication skill (Brignell et al., 2018; Ellis Weismer & Kover, 2015; Szatmari et al., 2003).

"Useful Speech" as Predictor

One early linguistic capability that is arguably most commonly invoked as an important predictor of outcome is the presence of "useful speech" at or around 5 years of age. Eisenberg (1956) was the first to observe that "the presence of useful speech" at 5 years of age predicts social and adaptive outcomes in individuals with ASD. Since 1956, numerous studies have replicated the finding that the presence of speech at approximately 5 years of age predicts a variety of later outcomes, such as language, social skills, autistic characteristics, and cognitive ability (e.g., Billstedt et al., 2007; DeMyer et al., 1973; Gillberg & Steffenburg, 1987; Rutter et al., 1967; Venter et al., 1992). However, "the presence of useful speech" was loosely defined by Eisenberg; he contrasted "speaking" individuals with "nonspeaking" individuals, who produced either no speech, exclusively echolalia, or only a few words "in a private sense" (Eisenberg, 1956, p. 608). Later studies that attempted to replicate Eisenberg's findings each provided a different definition of the predictive factor "useful speech" (e.g., presence of communicative speech before 5 years of age as noted in childhood records, speech with "communicative features," ≥ 5-word expressive vocabulary and age-equivalent score of 13 months on a vocabulary assessment, or simply "useful speech" or "communicative speech" with no elaboration), and they reported varying results. An important follow-up question, then, is what "useful speech" truly represents—that is, which area of language (morphology, syntax, semantics/vocabulary, or pragmatics) it is primarily capturing. This notion of "useful speech" may be enriched by exploring the larger body of literature on linguistic skills that best predict outcomes.

Semantics/Vocabulary as Predictor

Some evidence suggests that semantics may be an area of importance for adult outcome. Word learning milestones have been reported as predictors of later childhood outcome: Earlier age of first words predicts expressive language outcome at 45 months, and number of words produced at approximately 31 months predicts receptive, expressive, cognitive, and adaptive outcomes at 45 months (Kover et al., 2016). Childhood receptive and expressive vocabulary skill (as measured by standardized assessments or parent report measures) has been repeatedly identified as a significant predictor of later language, social, and adaptive outcomes in individuals with ASD (Howlin et al., 2000; Luyster et al., 2007; Venter et al., 1992).

Of note, vocabulary is also an important predictive variable in typical and atypical child language development. Armstrong et al. (2017) found that expressive vocabulary size at 2 years of age predicts the presence of autistic-like traits in adulthood in the general population. Rescorla (2005) found that, in late talkers and typically developing children, vocabulary at 2 years of age was the only significant predictor (when compared with socioeconomic status, nonverbal cognition, and receptive language skills) of vocabulary, grammar, verbal memory, and reading comprehension in adolescence; in the same study, vocabulary at 6 years of age was the most significant predictor (when compared with grammatical, phonological, and reading skills) of vocabulary, grammar, and reading comprehension in adolescence. More specifically, verbs may be a particularly important component of early vocabulary. Hadley et al. (2016) investigated the predictive power of early verb lexicon in typically developing toddlers, reporting that grammatical complexity at 40 months of age is better predicted by lexical *verb* diversity at 24 months of age than lexical *noun* diversity at 24 months of age. However, to our knowledge, the effect of early vocabulary composition on later language outcome has not yet been studied in individuals with ASD.

Morphosyntax as Predictor

Early skills in morphosyntax also seem to be prognostically indicative in ASD. Acquisition of phrase speech by 24 months is a significant predictor of sentence repetition ability and adaptive communication at 9 years of age (Kenworthy et al., 2012), and early receptive and expressive grammatical skills are a predictor of adolescent communication and adaptive skills (Bennett et al., 2008). Similarly, in children with specific language impairment (and not ASD), scores on an expressive syntax measure at 7 years of age significantly predicted language outcome (i.e., vocabulary, grammatical ability, semantic organization) at 11 years of age when compared with other language predictors (i.e., vocabulary, articulation, receptive grammar; Botting et al., 2001).

Functions of Language Use as Predictor

Finally, the use of speech for multiple purposes (i.e., other than requesting/protesting) has been proposed as an important skill in individuals with ASD, though its prognostic significance is relatively unknown. Children with ASD often have a restricted profile of communicative functions—using language primarily for behavior regulation (i.e., requesting/protesting) and less often for social functions (e.g., commenting, sharing attention)—relative to typically developing children (e.g., Shumway & Wetherby, 2009; Stone et al., 1997; Wetherby & Prutting, 1984). As a response to this difference in language use, treatment studies have focused on expanding the use of communicative functions in verbal children with ASD (e.g., Casenhiser et al., 2015; Raulston et al., 2013; Williams et al., 2000) and in those who use augmentative and alternative communication systems (e.g., Kasari et al., 2014; Logan et al., 2017). In their list of proposed benchmarks for evaluating expressive language development in children with ASD, Tager-Flusberg et al. (2009) suggest that using language for a variety of communicative functions by 5 years of age has predictive power (Paul & Cohen, 1984, as cited in Tager-Flusberg et al., 2009). The type of gestural communicative functions used by children with ASD has been linked to outcome: Mundy et al. (1990) reported that the use of gestures to direct the attention of others (compared with the use of gestures to request) by preschoolers with ASD significantly predicted language ability approximately 1 year later, while initial language score and IQ were not significant predictors. However, the prognostic significance of the types of *spoken* communicative functions an individual with ASD produces remains largely untested.

This Study

It is clear that childhood VIQ, overall language ability, and "useful speech" by 5 years of age are robust predictors of adult outcome in many areas. Childhood measures of ability in different language domains (i.e., semantics, morphosyntax, and pragmatics) have been independently proposed as important predictors, but to our knowledge, no prior studies have *compared* specific expressive language features across these language domains to investigate which features are the best predictors of adult outcome in individuals with ASD. Without such comparison, the notion of "useful speech" remains ambiguous; what exactly about early childhood language is most "useful" for individuals with ASD? Identification of specific language features in childhood that best predict outcome will enrich our understanding of the nature of language development in ASD, contribute to effective selection of intervention targets, guide the focus of future intervention studies, and enhance clinicians' ability to develop more detailed prognoses. Thus, this project aims to compare specific features of expressive language across language domains (i.e., semantics, morphosyntax, and pragmatics) in childhood to determine which features best predict adult language and communication outcomes in individuals with ASD.

Method

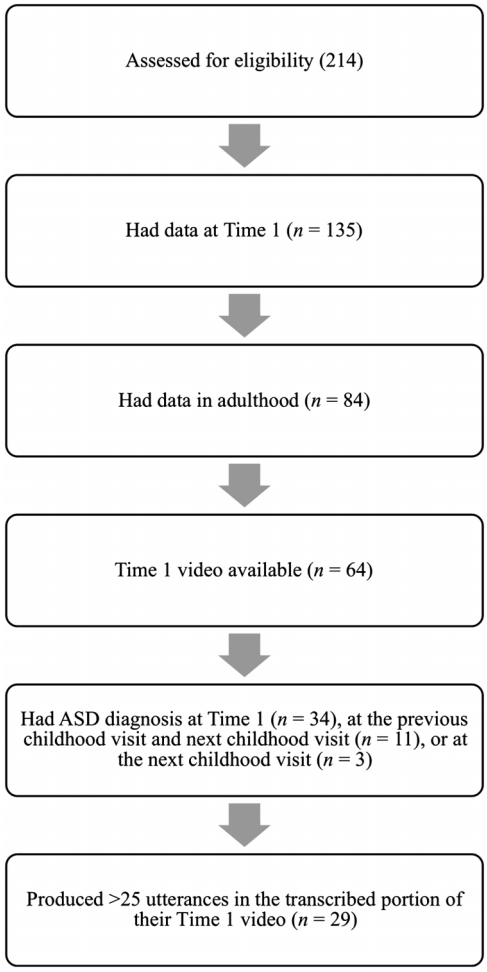
Participants

Data used for this study are from a longitudinal study of 192 children followed prospectively from age of referral for possible ASD (before 36 months) and 22 children in a developmental delay control group (e.g., Anderson et al., 2014, 2007; Lord et al., 2006). A variety of diagnostic, psychometric, and mood/behavior instruments were administered to some or all children at 2, 3, 5, 9, 18, 21, and 25 years of age; videos of administration of the Prelinguistic Autism Diagnostic Observation Schedule (PL-ADOS; DiLavore et al., 1995) or the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000) were recorded at each visit.

For the purposes of this study, we considered both the ASD referral group (n = 192) and the developmental delay control group (n = 22). All participants who had data collected at approximately 5 years of age (between the ages of 47 and 72 months, henceforth referred to as "Time 1") and at least once in adulthood were identified (n = 84). From this group, we excluded participants whose Time 1 videos were missing (n = 20), and from the resulting group, we excluded participants who did not have an autism spectrum diagnosis at Time 1 (n = 16).[1] This led to a group of 48 participants whose Time 1 videos were transcribed. Following transcription, any participant who produced fewer than 25 complete and intelligible spontaneous utterances in the analyzed portion of their Time 1 video was excluded (n = 19); prior language sample analysis studies have included samples of similar lengths (e.g., M. Dunn et al., 1996; Kover et al., 2014; Venker et al., 2015). This led to a final sample of 29 participants (24 male, five female; see Figure 1). Twenty-two of the participants (76%) were White, and seven (24%) were Black. Four of the participants' mothers (13.79%) had a high school education

[1]Some participants did not have diagnostic information available at Time 1 (n = 14). However, all had an autism spectrum diagnosis at the following visit in childhood (and, in most cases, at the prior visit at 2 years of age) and were thus included for transcription.

Figure 1. Participant inclusion/exclusion. At Time 1, participants were ages 47–72 months. Some participants did not have diagnostic information available at Time 1 (n = 14). Hence, diagnosis at the previous childhood visit and diagnosis at the next childhood visit were used to determine eligibility. ASD = autism spectrum disorder.



or less, over half (65.52%) had some college or a college degree, and five (17.24%) had graduate-level education. Based on the guidelines described by Koegel et al. (2020),[2] the sample contained nine children whom we considered minimally verbal at Time 1 (i.e., had a mean length of utterance [MLU] less than or equal to 2.0), three whom we considered limited verbal (i.e., had a MLU greater than 2.0 but did not consistently use generative language), and 17 whom we considered verbal (i.e., had an MLU greater than 2.0 and used generative language). See Table 1 for additional sample characteristics.

[2]Since we only had access to one short language sample from each participant, the classification of this sample based on verbal ability is tentative and provided here for general reference only. Ideally, to follow the guidelines outlined by Koegel et al. (2020), one would need to consider (at minimum) longer language samples across contexts and parent report data.

Measures

Predictor Variables (Time 1)

In the videos analyzed in this study, the PL-ADOS or ADOS was administered by one of seven individuals (four PhD-level clinical psychologists, a special educator, and two research assistants), all of whom were research reliable on the ADOS. ADOS activities were used as the language sampling context for this project, as other language samples were not available (see Kover et al., 2014, for a discussion of the use of the ADOS to derive language samples). The first 30 min of each video of Time 1 PL-ADOS or ADOS administration were transcribed and coded by the first author in order to standardize transcript length to the extent possible. Videos shorter than 30 min (n = 3, M = 20:27) were transcribed and coded in their entirety. The number of utterances analyzed ranged from 30 to 217 (M = 95.93, SD = 54.70). In addition to capturing typical morphosyntactic features, coding schemes were developed for lexical diversity and communicative functions.

Table 1. Participant characteristics.

Variable	*M*	*SD*	Range
Time 1			
Age (years)	4.62	0.55	3.92–5.75
NVIQ[a]	82.38	22.84	43–126
VIQ[b]	67.25	17.84	40–106
MLU in morphemes	2.61	0.87	1.27–4.92
Noun diversity	20.45	13.17	3–49
Verb diversity	18.82	11.28	2–44
Proportion of utterances that were socially motivated (%)	58.57	18.69	25–91.89
Time 2			
Age (years)[c]	24.37	3.37	18.42–30.08
NVIQ	87.79	32.89	18–133
VIQ	81.00	37.71	16–139
ADOS Communication + Social Interaction Algorithm total	10.76	4.44	2–19
Vineland-II Communication Domain standard score	70.34	27.62	21–119
PPVT-4 standard score[d]	78.04	33.61	23–124

Note. NVIQ = nonverbal IQ; VIQ = verbal IQ; MLU = mean length of utterance; ADOS = Autism Diagnostic Observation Schedule; Vineland-II = Vineland Adaptive Behavior Scales–Second Edition; PPVT-4 = Peabody Picture Vocabulary Test–Fourth Edition.

[a]One participant's NVIQ score was unavailable at 5 years of age; a score from 2 years prior was substituted. [b]One participant's VIQ score was unavailable at 5 years of age; the mean, standard deviation, and range are presented for the other 28 participants. [c]Adult age is based on date of administration of the ADOS. [d]One participant did not have a PPVT-4 score in adulthood. The mean, standard deviation, and range are presented for the other 28 participants, and the analyses were run including scores for the other 28 participants.

Lexical diversity. In order to determine noun diversity (i.e., number of different nouns produced) and verb diversity (i.e., number of different verbs produced), each unique noun and verb was coded following parameters outlined by Hadley et al. (2016). Nouns were defined as any words that could take preceding articles (i.e., *a, an, the*) and/or plural inflection (Hadley et al., 2016). Singular and plural nouns were counted as one noun type, as were diminutives (e.g., *horse* and *horsie* were counted as a single noun type). The words *one, this, that, these,* and *those* were considered pronouns, not nouns. Proper nouns (e.g., *Big Bird*, *Play-Doh,* sibling names) and kinship terms used to directly address others (e.g., *Mom*) were not coded for this measure, in keeping with previous work (Hadley et al., 2016). Kinship terms were included when referring to others indirectly (e.g., *my mom*). Verbs were defined as any words that could be inflected for tense, agreement, and/or aspect (Hadley et al., 2016). Only lexical verbs were coded (e.g., *go, see, give, want, sing, press, think*). Different inflections of the same verb (e.g., *watch, watching*) were counted as a single verb type, as were cliticizations/assimilations and their complete counterparts (e.g., *wanna* and *want [to]*, *lemme* and *let [me]*). Gerunds (e.g., *I like playing*) were not coded for this measure, following Hadley et al. (2016). The verb *got* (e.g., "I got a pencil" meaning *I have a pencil*) was counted as its own verb, separate from past-tense *got* and present-tense *have*. See Appendix A for codes and further details.

Communicative functions. Each complete, intelligible utterance was given a pragmatic code based on its communicative function. The pragmatic coding scheme was based on Dore (1974), Chapman (1981, as cited in Hoff, 2013), and Bauminger-Zviely et al. (2017). The following communicative functions were included for this project: asserting, requesting, information seeking, answering, calling, greeting/politeness forms, protesting, conversational maintenance, dubbing, nonreciprocal/other, and repeating. All codes were mutually exclusive, *except* repeating (i.e., each utterance was assigned *one* pragmatic code, and repeating was coded whenever relevant). See Appendix B for codes and further details.

Following initial transcription and coding, second listeners (trained communication sciences and disorders students) reviewed each transcript while watching the corresponding video and made comments and changes when necessary. The first author reviewed all comments and changes and then met with second listeners to resolve any discrepancies. If questions remained, a third listener (either the second or last author) was consulted. Each finalized transcript was analyzed using the Systematic Analysis of Language Transcripts (SALT; Miller & Iglesias, 2015) software.

Initially, potential predictor variables were identified as representative measures of three language domains: morphosyntax, semantics, and pragmatics.[3] In the domain of morphosyntax, MLU in morphemes was selected, as it is a reliable and valid measure of overall morphosyntactic development in the preschool period, including for individuals with ASD (Paul & Norbury, 2012; Tager-Flusberg et al., 1990). MLU was chosen over other possible measures for two reasons. First, it is a more general measure of morphosyntax than other measures (e.g., Finite Verb Morphology

[3]Note that phonology was excluded from this study, since the audio in the available videos was not of high enough quality to allow phonological transcription.

Composite, which looks at use of specific tense and agreement morphemes). Second, MLU is a clinically relevant variable; best practice guidelines suggest calculating MLU as part of an assessment of language development in young children with ASD and/or language disorders (Paul & Norbury, 2012; Tager-Flusberg et al., 2009).

In the domain of semantics, noun diversity and verb diversity were selected based on prior research identifying them as predictors of later grammatical outcome in typically developing children (Hadley et al., 2016). These variables were chosen over other, more general semantic measures (e.g., number of different words, number of total words, type–token ratio) to compare these two lexical categories (i.e., nouns and verbs) as predictors, particularly since noun learning is often disproportionately emphasized in interventions for individuals with ASD.

Finally, in the domain of pragmatics, several related measures were originally chosen based on a set of benchmarks for evaluating and describing spoken language ability in children with ASD, which includes use of communicative functions as a measure of pragmatics (Tager-Flusberg et al., 2009). We chose to investigate this area of pragmatics (i.e., communicative functions) in particular due to its clinical relevance; treatment for children with ASD often focuses on increasing the number of different communicative functions that the child uses (e.g., Casenhiser et al., 2015; Kasari et al., 2014; Logan et al., 2017; Raulston et al., 2013). The pragmatic measures originally chosen were the number of different communicative functions used, the proportion of utterances that served behavior regulation functions (i.e., requesting, protesting), and the proportion of utterances that were socially motivated (i.e., asserting, information seeking, answering, calling, greeting/politeness forms, conversational maintenance, dubbing, repeating).

These six variables—MLU, noun diversity, verb diversity, number of communicative functions used, proportion of utterances that served behavior regulation functions, and proportion of utterances that were socially motivated—were extracted or derived from each transcript. NVIQ was also identified for use as a control variable, in keeping with previous work that included NVIQ as a variable of interest (e.g., Anderson et al., 2014; Howlin et al., 2004; Kenworthy et al., 2012; Wodka et al., 2013). MLU was derived from complete and intelligible spontaneous utterances. For extraction of communicative functions codes, nonspontaneous utterances (e.g., yes/no responses, imitations) were included, since they served a communicative purpose. For extraction of nouns and verbs, all spontaneous utterances were analyzed, because the use of a noun or verb could be determined even from an incomplete or partially unintelligible utterance. The Explore > List feature in SALT was used to extract utterances that included each relevant word- or utterance-level code. Childhood language sample measures that were count variables (i.e., noun diversity and verb diversity) were divided by the number of minutes in the sample to standardize numbers across videos of different lengths.

To eliminate redundancy, Pearson correlations between the three potential pragmatics predictors and the adult outcome variables were analyzed. Proportion of utterances that were socially motivated was the most significantly and consistently associated with outcome variables; the other two pragmatics predictors (number of communicative functions used and proportion of utterances that served behavior regulation functions) were dropped.

Then, multicollinearity was assessed via variance inflation factor (VIF) in a regression model with NVIQ, MLU, noun diversity, verb diversity, and proportion of socially motivated utterances as predictor variables. The VIF values for MLU and verb diversity were highest (4.073 and 5.242, respectively); VIF of greater than 5 indicates problematic multicollinearity (e.g., James et al., 2017). When either MLU or verb diversity was removed from the regression, all VIF values were less than 3, indicating that the multicollinearity assumption required for linear regression was satisfied when these two variables were not included in the same model. We conducted two sets of analyses—one with MLU and the other with verb diversity—in order to retain both variables as potential predictors but avoid problematic multicollinearity. The final set of predictor variables for Analysis 1 included NVIQ, noun diversity (semantics), verb diversity (semantics), and proportion of utterances that were socially motivated (pragmatics). The final set of predictor variables for Analysis 2 included NVIQ, MLU (morphosyntax), noun diversity (semantics), and proportion of utterances that were socially motivated (pragmatics). See Table 1.

Outcome Variables (Time 2)

The following adult language and communication outcome variables were used for our analyses: VIQ standard scores, ADOS or ADOS-2 (Lord et al., 2012) Communication + Social Interaction Algorithm totals,[4] Peabody Picture Vocabulary Test–Fourth Edition (PPVT-4; L. M. Dunn & Dunn, 2007) standard scores, and Vineland Adaptive Behavior Scales–Second Edition (Vineland-II; Sparrow et al., 2005) Communication Domain standard scores. See Table 1.

Analysis

In order to assess the predictive power of each Time 1 variable, we used hierarchical linear regression to identify value-added predictors (e.g., Yoder et al., 2015): predictors that led to a significant change in R^2 when added to the model last. All assumptions for linear regression were satisfied. We conducted two sets of analyses, as described above—one included MLU among the potential predictors, and the other included verb diversity. In both sets of analyses, Time 1 NVIQ was entered into the model first as a control variable. Two other predictor variables

[4]Some participants received the original ADOS in adulthood, while others received the ADOS-2, depending on the year in which the assessment occurred. Modules 1–3 of the ADOS-2 do not include a Communication total or Social Interaction total; these scores were derived separately for individuals who received the ADOS-2, using the same formula that was used to calculate these scores on the original ADOS.

were added in the second block, and the final variable was added in the third block. In both sets of analyses, three regression models were run for each outcome variable, with a different predictor variable added in the third block each time. If the final variable added led to a significant change in R^2 for the model as determined by an F test with a p value of < .05, it was identified as a value-added predictor.

Results

Analysis 1

Results from multiple hierarchical linear regressions with NVIQ, noun diversity, verb diversity, and proportion of utterances that were socially motivated as predictors are presented in Table 2. In this analysis, Time 1 verb diversity was a value-added predictor of every Time 2 outcome: VIQ (p = .027), ADOS Communication + Social Interaction Algorithm totals (p = .003), PPVT-4 scores (p = .011), and Vineland-II Communication scores (p = .034). Conversely, Time 1 noun diversity and proportion of utterances that were socially motivated were not value-added predictors of any analyzed Time 2 outcomes.

Analysis 2

In a second set of analyses, MLU replaced verb diversity as a predictor variable. Results from multiple hierarchical linear regressions with NVIQ, noun diversity, MLU, and proportion of utterances that were socially motivated as predictors are presented in Table 3. In this analysis, Time 1 MLU was a value-added predictor only of Time 2 VIQ (p = .016) and Vineland-II Communication Domain scores (p = .045). MLU was not a value-added predictor of Time 2 ADOS Communication + Social Interaction Algorithm totals or PPVT-4 scores, though it approached significance as a value-added predictor for PPVT-4 scores (p = .051). The pattern of findings for the other two potential predictor variables was the same as in the previous analyses.

Discussion

In our analyses, a remarkably consistent pattern emerged: Childhood verb diversity—a measure of semantics—was a value-added predictor of all four adult language and communication outcomes. Childhood MLU was a value-added predictor of two of the adult outcomes, but not the other two. The other childhood variables (i.e., NVIQ, noun diversity, and proportion of utterances that were socially motivated) were not value-added predictors of any adult outcomes. The results of this study help clarify the notion of "useful speech," contributing specificity to our understanding of early language ability as a predictor of language and communication outcome in individuals with ASD.

Our finding that verb diversity was the best predictor of the analyzed adult language and communication outcomes aligns with prior studies identifying early vocabulary as a predictor of language outcome in individuals with ASD (Howlin et al., 2000; Luyster et al., 2007; Venter et al., 1992). This study expands on previous findings by identifying a specific area of vocabulary (verb diversity) that most significantly predicts outcome and by investigating the relative strength of this predictor when compared to other areas of early language.

Our finding that language and communication outcome was better predicted by verb diversity than noun diversity in this sample mirrors the findings of Hadley et al. (2016), who reported that grammatical complexity at 30 months in typically developing children is better predicted by lexical verb diversity at 24 months than noun diversity. Our results extend these findings in three ways. First, we used a wider range of outcome variables. Second, we investigated predictive relations over a much longer time period (i.e., early childhood to early adulthood). Third, we studied a different population: individuals with ASD. Overall, our finding that verb diversity was a better predictor than noun diversity in this sample suggests that the long-term significance of vocabulary size depends partly on word type for individuals with ASD.

Despite previous findings linking social skills with later language outcomes (e.g., Sigman & McGovern, 2005; Wodka et al., 2013) and studies that allude to the importance

Table 2. Analysis 1: Value-added predictors of adult language outcome.

	Adult outcome variable							
	VIQ		ADOS		PPVT-4		Vineland-II	
Childhood predictor variable	R^2 change	p	R^2 change	p	R^2 change	p	R^2 change	p
Noun diversity	.02	.361	.08	.070	.03	.313	.01	.515
Verb diversity	.12	.027	.26	.003	.18	.011	.14	.034
Proportion of utterances that were socially motivated	.04	.186	.05	.142	.02	.384	.00	.921

Note. p values indicate the significance of the change in R^2. VIQ = verbal IQ; ADOS = Autism Diagnostic Observation Schedule or Autism Diagnostic Observation Schedule–Second Edition Communication + Social Interaction Algorithm totals; PPVT-4 = Peabody Picture Vocabulary Test–Fourth Edition standard scores; Vineland-II = Vineland Adaptive Behavior Scales–Second Edition Communication Domain standard scores.

Table 3. Analysis 2: Value-added predictors of adult language outcome.

Childhood predictor variable	Adult outcome variable							
	VIQ		ADOS		PPVT-4		Vineland-II	
	R^2 change	*p*	R^2 change	*p*	R^2 change	*p*	R^2 change	*p*
Noun diversity	.00	.666	.01	.606	.00	.994	.00	.991
MLU in morphemes	.15	.016	.10	.077	.12	.051	.13	.045
Proportion of utterances that were socially motivated	.02	.335	.03	.312	.01	.643	.00	.825

Note. *p* values indicate the significance of the change in R^2. VIQ = verbal IQ; ADOS = Autism Diagnostic Observation Schedule or Autism Diagnostic Observation Schedule–Second Edition Communication + Social Interaction Algorithm totals; PPVT-4 = Peabody Picture Vocabulary Test–Fourth Edition standard scores; Vineland-II = Vineland Adaptive Behavior Scales–Second Edition Communication Domain standard scores.

of expanding the types of communicative functions used by children with ASD (e.g., Kasari et al., 2014; Logan et al., 2017; Tager-Flusberg et al., 2009), our childhood measure of pragmatics was not a value-added predictor of the language and communication outcomes that we analyzed. These results are consistent with at least one prior study that did not identify early social ability as a significant predictor of later language (Brignell et al., 2018). However, our childhood measure of pragmatics (i.e., proportion of utterances that were socially motivated) only captured one area of pragmatics: use of communicative functions/speech acts. Furthermore, though we based our coding scheme on prior taxonomies of speech acts in early language development, there are many different ways of capturing speech acts at varying levels of complexity, and no single taxonomy is considered standard. Future studies should investigate whether verb diversity remains a value-added predictor when compared with more nuanced and comprehensive measures of pragmatic skill. Studies investigating the effects of treatments that target expansion of communicative functions will help further elucidate the relationship between use of communicative functions and later outcome. Nonetheless, our findings serve as a reminder that, despite the importance of early social communication intervention for the development of social communication and social skills (e.g., Fuller & Kaiser, 2019; Wolstencroft et al., 2018), an early focus on structural language is also vital when considering adult language and communication outcomes.

We also acknowledge that children who have a larger verb vocabulary are likely using verbs more flexibly across a wider variety of linguistic and pragmatic contexts. However, that does not necessarily mean that children with larger verb vocabularies are using verbs more socially (i.e., flexibility in use across contexts does not necessarily imply specific growth in use of social verbs). In fact, recent work suggests that autistic children with smaller verb vocabularies tend to use approximately the same number of social verbs as those with larger verb vocabularies (Jiménez et al., 2020). One interesting follow-up question is how growth in verb vocabulary relates to broader pragmatic skills (e.g., whether the number of verbs used for behavior regulation vs. social interaction changes as verb vocabulary grows). In general, future studies could continue to investigate the connection between verbs and pragmatics by further exploring types of verbs used by children with ASD, as well as verb use in context.

Though the reason why verb diversity may be particularly important for later language and communication outcomes is unknown, we offer several hypotheses. First, verbs play not only a semantic role but also a syntactic role, as they are syntactically more complex and essential than other lexical categories. As part of the Natural Partitions hypothesis, Gentner (1982) noted that nouns generally express referential meanings, while verbs express relational meanings—even when considered alone, the meaning of a verb is relational in that it implies connection among ideas or states. Syntactically, too, verbs are essential in denoting these connections: Verbs comprise the only lexical category syntactically required to form a clause (e.g., Beavers et al., 2010). In simpler terms, the verb is the "core of the sentence" (Gentner & Boroditsky, 2001, p. 243), both syntactically and semantically. Given the syntactic complexity and uniqueness of verbs, childhood verb diversity could be described as a measure of both semantic and syntactic skill, particularly since verb learning often involves syntactic knowledge (syntactic bootstrapping; Gleitman, 1990). The prognostic significance of verb diversity for later language and communication outcomes, then, may be explained by the fact that it likely measures multiple areas of linguistic skill.

Second, since verbs express referential meanings, they are more abstract than nouns in most cases (e.g., Gentner, 1978). If a child is using more verbs, we might posit that they also have a better understanding of abstract relationships among objects and ideas in the world. So, verb diversity may be capturing a child's higher level knowledge more than other early language measures do, providing some explanation for its prognostic significance. Third, verb diversity may have been a better predictor in this study than our measure of pragmatics simply because we looked at language and communication outcome measures rather than more social, ASD-specific outcome measures (e.g., ASD severity, paralinguistic/extralinguistic social skills). When looking at outcomes like these, verb diversity may prove a less powerful predictor.

Limitations

This study is limited by its small sample size, which likely does not represent the full range of the autism spectrum. Additionally, to ensure that language samples were representative of a child's true ability, participants were excluded

if they produced fewer than 25 complete, intelligible utterances during the selection of video that was analyzed. This meant that all preverbal children and many minimally verbal children were excluded, though, as described above, 12 participants included in this study may be considered minimally/limited verbal at Time 1 following an approximation of the classification outlined by Koegel et al. (2020). Our sample also had a relatively wide NVIQ range in childhood (43–126) and adulthood (18–133). Nonetheless, we acknowledge that our sample does not represent the entire autism spectrum, given constraints imposed by the available data and by the language sample analysis process.

Another limitation in this study is the use of the ADOS as a language sampling context. Some researchers have identified the ADOS as a natural language sampling context (Tager-Flusberg et al., 2009), yet others have found that children's language performance during the ADOS differs significantly from their language performance during play with a parent or examiner (Kover et al., 2014). Kover et al. (2014) reported that, during the ADOS, children with autism produced fewer utterances and fewer words, were less intelligible, and had lower MLU than when engaged in play with their parent or an examiner. We acknowledge that the ADOS is a less ideal context for assessing language performance than a language sample during play with an adult, and we thus encourage readers to interpret these results with caution. However, language samples were not otherwise available in this longitudinal data set.

Measures of phonology were excluded as potential predictors in this study, since phonological transcription was not possible due to the audio quality of the available videos. Phonological and articulation skills generally have not been identified as robust predictors of later morphosyntactic, semantic, or vocabulary outcomes in individuals with language impairment or who were referred early for language concerns (e.g., Bishop & Edmundson, 1987; Botting et al., 2001; Chiat & Roy, 2013). However, some research reports that early phonetic inventory in minimally verbal preschoolers with ASD predicts language growth (Saul & Norbury, 2020; Yoder et al., 2015). Future studies more inclusive of minimally/limited verbal individuals will want to consider whether early phonological skills may be more important predictors than early semantic skills in the minimally/limited verbal population.

Finally, language and communication scores on standardized assessments were the only outcomes analyzed in this study. As noted earlier, many other important outcomes are correlated with language/communication skill in adulthood (e.g., social skills, friendships, adaptive skills, academic ability, employment). These and other related areas (e.g., quality of life, breadth and quality of leisure activities, independent living status) should be explored as outcome measures in future studies that further investigate the importance of early verb diversity.

Clinical Implications and Future Directions

Identification of verb diversity as a value-added predictor of adult language and communication outcome can contribute to effective selection of intervention targets, particularly in the preschool period. The prior finding that language development is most variable before the age of 6 years underscores the importance of effective intervention during the preschool and early school–age period, when children's language may be most sensitive to input (Pickles et al., 2014). Thus, targeting verb diversity in these early years, when the most language change is occurring and the overall linguistic system is most malleable, may be quite powerful for later language outcome. Our finding that MLU was a value-added predictor of some adult language and communication outcomes in this sample can also guide clinical decisions in the preschool period; targeting MLU and verb diversity simultaneously could prove particularly effective. Our results suggest that interventions targeting noun learning or pragmatics alone may not be as powerful when considering long-term language and communication outcome. Future studies should test these intervention hypotheses.

Our results may also support clinicians' ability to identify clients at greater risk for long-term language difficulties. Despite our ability to diagnose ASD at increasingly younger ages, children in the United States are not diagnosed until 51 months of age, on average (Maenner et al., 2020). In light of this, clinicians must be prepared to consider what factors in the late preschool period may influence their clients' development. Our findings suggest that clinicians may want to consider verb diversity, and potentially MLU, as one of many behavioral factors that can contribute to language progress and outcome in children with ASD.

In summary, childhood verb diversity was identified as a value-added predictor of all adult language and communication outcomes, and childhood MLU was identified as a value-added predictor of some, but not all, outcomes. Other analyzed childhood language features were not value-added predictors of any analyzed outcomes. This supports the idea that the diversity of early verb lexicon may have the most significant predictive power for later language and communication outcomes in individuals with ASD. This phenomenon may be due to the unique features of verbs that seem to allow them to capture skill in multiple language domains (i.e., semantics and syntax). These findings have implications for our understanding of early childhood language in ASD and clinical decision making in the preschool period. We hope that these findings will lead to the development of future intervention studies investigating the feasibility and effects of targeting expansion of verb lexicon in young children with ASD.

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Appendix A

Lexical Diversity Codes

*Do not code nouns or verbs in echolalic phrases, routinized utterances, or imitated phrases within the ADOS imitation task.
For coding purposes, the following definitions were used:
- Immediate echolalia: Immediate repetition (within two utterances of the initial utterance) of a previous utterance or partial utterance made by the parent/caregiver or examiner; mimics intonation (Prizant & Duchan, 1981).
- Delayed echolalia: Repetition of a previous utterance or partial utterance made by the parent/caregiver or examiner occurring more than two utterances subsequent to the model utterance; mimics intonation. OR Utterance that is beyond the syntactic and/or semantic complexity of spontaneous/generative utterances (Prizant & Rydell, 1984). OR Utterance that is scripted and/or out of context (not including nursery rhymes and songs).
- Routinized utterances: Reciting ABCs, counting, songs, nursery rhymes, scripted utterances within a social routine (e.g., "Where's mommy?" during peekaboo, "Ready, set, go" within a variety of games).

Nouns **Code (word level) [n]**

Code all nouns. After Hadley et al. (2016), nouns are defined as any word that can take a preceding article *a/an/the* or a plural morpheme. Exclude proper nouns (e.g., Cookie Monster, Big Bird, Mom).

Example: C Throw ball[n].

Verbs **Code (word level) [v]**

Code all verbs. After Hadley et al. (2016), verbs are defined as any word that carries semantic meaning and can be inflected for past-tense *–ed,* agreement *–s,* and/or aspect *–ing*.

Example: C Throw[v] ball.

*Only code lexical verbs (i.e., exclude copula, auxiliary, and gerunds).

*Note that in a construction such as "I want to play" or "I wanna go," the *want to/wanna* form and the infinitive verb *to X* should both be coded as verbs. Example: C I want[v] to play[v].

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Pragmatic Codes: Speech Acts/Communicative Functions

Code each utterance with one of the following speech acts (Bauminger-Zviely et al., 2017; Chapman, 1981, as cited in Hoff, 2013; Dore, 1974).

*These codes are mutually exclusive; each utterance should only be coded with *one* pragmatic function. Repeating is the only pragmatic function that is *not* mutually exclusive; it can be layered on top of other pragmatic codes.
*Code spontaneous *and* nonspontaneous utterances for pragmatics.
*Do not code partially unintelligible or incomplete (interrupted or abandoned) utterances for pragmatics.
*Do not code nonword "utterances" (e.g., whining as protest, vocalizing as request) for pragmatics.

Asserting (labeling, commenting, describing) — **Code (utterance level) [Assert]**
Communicating in order to share information about external objects/events/people or internal states.

Examples:
Looking at Cookie Monster toy and saying, "cookie," "blue," "It's Cookie Monster," "Cookie Monster is so cute," etc.
Saying, "I'm hungry."

Requesting — **Code (utterance level) [Req]**
Communicating in order to obtain something, express desire, or demand/command.
Examples: "bubbles," "tickle me," "I want apple juice," "Will you open the door?"
Permission questions (e.g., "Can I do it?") fall into this category.

Information Seeking — **Code (utterance level) [InfSeek]**
Asking a question in order to obtain information.
Examples: "What time is it?" "Where's mom?"

Answering — **Code (utterance level) [Ans]**
Answering a question asked by another person.

Calling — **Code (utterance level) [Call]**
Calling the name of another person to get their attention.

Greeting/Politeness Forms — **Code (utterance level) [Grt]**
Greeting an object or person. Includes hellos, goodbyes, goodnight greetings, and politeness forms (e.g., "thank you," "bless you," "sorry").

Protesting — **Code (utterance level) [Prt]**
Resisting the actions or words of another person.

Example: E Now they're gonna eat.
C No eat [Prt].

Conversational Maintenance — **Code (utterance level) [Maint]**
Utterances whose primary purpose is to maintain an interaction/conversational flow. This includes clarification/confirmation questions (e.g., "Huh?" "What?" "Don't put that back?"), filler/empty words and phrases (e.g., "yeah?" "mhmm," "oh"), agreement statements (e.g., "yep," "yeah" when *not* answering a yes/no question), and participation in reciprocal games (e.g., "Where's mommy?" while playing peekaboo).

Dubbing — **Code (utterance level) [Dub]**
Utterances that a child produces (likely during symbolic play) from an object or another person's point of view (i.e., as if the object or other person were speaking).
Example: making a doll say, "Let's eat!"

Nonreciprocal/Other — **Code (utterance level) [Nonrecip]**
This includes (a) utterances that the child does not direct toward another person (i.e., using language just to "practice") and (b) utterances that cannot be determined with certainty to fit into one of the categories listed above.
Examples: pretending to talk on the phone, counting, singing, scripted speech in the absence of any particular object or event.

Appendix B (p. 2 of 2)

Pragmatic Codes: Speech Acts/Communicative Functions

Perseverative utterances and delayed echolalia can fall into this category, as long as you determine that they are not clearly serving another pragmatic function.

Repeating **Code (utterance level) [Rpt]**

This code should be used *whenever* a child repeats part or all of the immediately preceding preceding adult utterance. This code is *not* mutually exclusive; it can be layered on top of any other pragmatic code. However, it can also be used on its own.

Examples: E Look at the book.
C Book [Rpt].
E Do you want some more?
C Some more [Ans] [Rpt].

*During the Imitation portion of the ADOS, utterances may be coded as Repeating even if they are not immediately following the model adult utterance.

Example: E Yum yum, yum yum.
E You do it.
+ C Yum yum, yum yum [Rpt].