JSLHR

Research Article

Predicting Receptive–Expressive Vocabulary Discrepancies in Preschool Children With Autism Spectrum Disorder

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Purpose: Correlates of receptive–expressive vocabulary size discrepancies may provide insights into why language development in children with autism spectrum disorder (ASD) deviates from typical language development and ultimately improve intervention outcomes.
Method: We indexed receptive–expressive vocabulary size discrepancies of 65 initially preverbal children with ASD (20–48 months) to a comparison sample from the MacArthur–Bates Communicative Development Inventories Wordbank (Frank, Braginsky, Yurovsky, & Marchman, 2017) to quantify typicality. We then tested whether attention toward a speaker and oral motor performance predict typicality of the discrepancy 8 months later.
Results: Attention toward a speaker correlated positively with receptive–expressive vocabulary size discrepancy typicality. Imitative and nonimitative oral motor performance were not significant predictors of vocabulary size discrepancy typicality. Secondary analyses indicated that midpoint receptive vocabulary size mediated the association between initial attention toward a speaker and end point receptive–expressive vocabulary size discrepancy typicality.
Conclusions: Findings support the hypothesis that variation in attention toward a speaker might partially explain receptive–expressive vocabulary size discrepancy magnitude in children with ASD. Results are consistent with an input-processing deficit explanation of language impairment in this clinical population. Future studies should test whether attention toward a speaker is malleable and causally related to receptive–expressive discrepancies in children with ASD.

In contrast to delayed language development, which follows the typical course but at a slower rate, deviant language development is characterized by patterns of skills not observed in typical development (Kamhi, 1998; Loeb & Leonard, 1991). An atypical discrepancy between receptive and expressive language skills exhibited by some children with autism spectrum disorder (ASD) is one manifestation of deviant language development (e.g., Davidson & Ellis Weismer, 2017; Hudry et al., 2010; Kim, Paul, Tager-Flusberg, & Lord, 2014; Luyster, Kadlec, Carter, & Tager-Flusberg, 2008). Correlates of the magnitude of receptive–expressive discrepancy patterns may provide insights into why language development in ASD deviates from typical language development. In turn, these insights may guide the development and use of more effective language intervention strategies. We evaluate two theoretically motivated and potentially malleable predictors of receptive–expressive vocabulary size discrepancies in children with ASD as an early step in understanding individual differences in the direction and magnitude of receptive–expressive vocabulary discrepancies in children with ASD.

In this introduction, we first review the discrepancy between receptive and expressive vocabulary sizes in typical development. Then, we describe how previous studies have evaluated the discrepancies between receptive and expressive modalities of children with ASD and observed variability within and across the studies. Next, we discuss previously tested predictors of receptive–expressive vocabulary discrepancies in children with ASD. Finally, we provide a specific rationale for testing two theoretically motivated and potentially malleable predictors of receptive–expressive vocabulary size discrepancies in children with ASD: (a) attention toward a speaker and (b) oral motor performance.

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Editor-in-Chief: Sean Redmond
Editor: Magaret Kjelgaard
Received March 17, 2017
Revision received August 1, 2017
Accepted February 8, 2018
https://doi.org/10.1044/2018_JSLHR-L-17-0101

Disclosure: The authors have declared that no competing interests existed at the time of publication.

The Discrepancy Between Receptive and Expressive Vocabulary Size in Typical Development

Individuals who are typically developing exhibit much larger receptive vocabularies than expressive vocabularies across the life span. Children demonstrate comprehension of spoken words prior to using them and build receptive vocabularies faster than expressive vocabularies (Benedict, 1979; Fenson et al., 1994, 1993, 2007; Owens, 2008). Based on the MacArthur–Bates Communicative Development Inventories Wordbank (MB-CDI), Fenson et al. (2007) reported the emergence of spoken word comprehension around 8–10 months, but still minimal spoken word use at 12 months. At 16 months, spoken word use increased to a median of 40 words with receptive vocabulary size increasing to a median of 169 words—a difference of 129 words (Fenson et al., 1994). Receptive vocabulary size continues to exceed expressive vocabulary size not only in childhood but also in adulthood. First graders, for instance, exhibit receptive vocabularies of 8,000–14,000 words and expressive vocabularies of approximately 2,600 words (Anglin, Miller, & Wakefield, 1993). For adults, receptive vocabularies are estimated to be about twice the size of expressive vocabularies (Brysbaert, Stevens, Mandera, & Keuleers, 2016; Goulden, Nation, & Read, 1990).

Prior Investigations of Receptive–Expressive Vocabulary Discrepancies in Children With ASD

As with children with typical developmental histories, children with ASD are expected to comprehend more words than they produce. However, the degree to which this discrepancy is atypically smaller or larger than in typically developing children and why this atypical discrepancy exists is of interest because it could lead to testable hypotheses about why language development is deviant in children with ASD. The relation between receptive and expressive language skills of children with ASD has received notable attention in the literature. It appears that children with ASD exhibit atypical receptive–expressive vocabulary discrepancies that vary in direction and magnitude within and across studies with some studies reporting nonsignificant results. For example, Kover, McDuffie, Hagerman, and Abbeduto (2013) reported that boys with ASD aged 4–11 years old demonstrated slower growth in receptive vocabulary relative to expressive vocabulary using the Peabody Picture Vocabulary Test (Third and Fourth Editions; Dunn & Dunn, 1997, 2007) and the Expressive Vocabulary Test (First and Second Editions; Williams, 1997, 2007). In contrast, Kjelgaard and Tager-Flusberg (2001) did not identify differences in group means for receptive and expressive vocabulary skills, also using the Peabody Picture Vocabulary Test and Expressive Vocabulary Test with children with ASD aged 4–14 years old. Kover et al. (2013) and Kjelgaard and Tager-Flusberg (2001) reported that 28% and 20% of the participants with ASD, respectively, showed discrepant receptive–expressive vocabulary profiles.

Relative to studies of developmentally older children, studies of developmentally younger children with ASD using the MB-CDI have reported smaller receptive–expressive vocabulary size discrepancies in children with ASD compared with the normative sample more consistently. However, variation in the magnitude of differences between the normative sample and study samples matched on receptive vocabulary level is apparent (Charman, Drew, Baird, & Baird, 2003; Hudry et al., 2010; Luyster et al., 2008). Sampling error may contribute to across-study variability in conclusions regarding the vocabulary discrepancy wherein some studies identify group mean differences in receptive and expressive vocabulary skills and others do not. That is, the existence of subgroups with opposing differences that cancel out one another might be occurring in studies that do not find the atypical receptive–expressive vocabulary size discrepancy. In summary, the across-study variability in the presence and degree of receptive–expressive vocabulary discrepancies suggests probable variability of such in the population of children with ASD. However, the degree of typicality of receptive–expressive discrepancies for children with ASD can only be inferred from past studies because they rarely examine within-child discrepancies directly.

The current study investigates variation in the degree of typicality of receptive–expressive vocabulary size discrepancies for children with ASD. Several other approaches that have been used to evaluate receptive–expressive language discrepancies in prior studies do not answer questions regarding the typicality of receptive–expressive vocabulary size discrepancies in children with ASD. For example, studies that compare receptive versus expressive modalities in aspects of language other than vocabulary may be irrelevant to the current study (e.g., Pickles, Anderson, & Lord, 2014; Volden et al., 2011). In addition, attempting to combine studies that examine potentially discrepant standard scores or age equivalencies with those that examine potentially discrepant raw scores across receptive versus expressive modalities confuses the discrepancy question (Kwok, Brown, Smyth, & Cardy, 2015). Even for studies focusing on vocabulary, neither standard scores nor age equivalencies permit comparison of within-child discrepancies in receptive–expressive vocabulary size (e.g., Ellis Weismer, Lord, & Esler, 2010; Kjelgaard & Tager-Flusberg, 2001; Maljaars, Noens, Scholte, & van Berckelaer-Onnes, 2012).

Previously Investigated Predictors of Receptive–Expressive Discrepancies in Children With ASD

Investigating correlates of variability in the relative discrepancies in receptive–expressive vocabulary size has two advantages. First, it acknowledges the likely variability in the magnitude and direction of atypical receptive–expressive vocabulary discrepancies in children with ASD. Second, correlates of the variability in receptive–expressive vocabulary discrepancies might offer a step toward understanding the cause. We acknowledge that correlates are not necessarily causes of the vocabulary discrepancy. However, they do have potential importance for causal theories. That is, if a variable is not correlated with the vocabulary discrepancy, it cannot be the cause of it. Once correlates of the vocabulary discrepancy are identified, we can conduct future experiments to test whether this association is causal.

A limited number of prior studies have investigated a small set of children's characteristics in an attempt to identify which children with ASD will exhibit atypical receptive–expressive discrepancies in language skills. Nonverbal cognitive abilities have predicted the presence of atypical receptive–expressive language discrepancies (Hudry et al., 2010) and the difference between receptive and expressive vocabulary growth scores (Kover et al., 2013). However, nonverbal cognitive abilities have not been identified as a significant predictor in all studies (Haebig & Sterling, 2017). Similarly, Hudry et al. (2010) identified group differences in ASD severity for groups of children with ASD who did versus did not exhibit atypical receptive–expressive profiles on the MB-CDI, but ASD severity did not predict receptive–expressive difference scores in the Kover et al. (2013) sample. Mixed results are also evident for chronological age (Davidson & Ellis Weismer, 2017; Haebig & Sterling, 2017; Hudry et al., 2010; Kover et al., 2013; Kwok et al., 2015). None of these predictors are clearly malleable in children with ASD. In addition, the broad nature of these predictors does not permit evaluation of more specific theories of language development in children with ASD.

Considering potentially malleable predictors offers additional promise for influencing intervention to improve outcomes. Chawarska, Macari, and Shic (2012) assessed whether a more specific child variable—visual attention to a speaker—correlated with receptive–expressive language skill discrepancies in 13- to 25-month-old children with ASD. Results indicated that children with greater deficits in receptive language relative to expressive language on the Mullen Scales of Early Learning (MSEL; Mullen, 1995) tended to look less at the speaker's mouth and face than those with less atypical discrepancies. Importantly, because the participants achieved a mean mental age for verbal abilities on the MSEL of 9.1 months (SD = 5.8 months), their overall spoken word vocabulary sizes likely were small, and a number of the MSEL items included prelinguistic skills. Consequently, it is unknown whether visual attention to a speaker correlates with future differences in receptive–expressive vocabulary size discrepancies in children with ASD. Such correlates of the magnitude of receptive–expressive vocabulary size discrepancies are of interest because of their potential influence on intervention strategies.

Two Theoretically Motivated and Potentially Malleable Predictors of Receptive–Expressive Vocabulary Size Discrepancy

Identifying malleable predictors could improve the probability of addressing the language learning challenges of many children with ASD. We selected two candidate predictors of the typicality of receptive–expressive vocabulary size discrepancy that are consistent with contrasting theories of why many children with ASD have atypical language development: (a) attention toward a speaker and (b) oral motor performance. The theories associated with deficits in attention toward a speaker and oral motor performance predict receptive–expressive vocabulary size discrepancies in opposite directions. The speech attunement theory posits that relatively poor attention toward a speaker tends to reduce the amount that receptive vocabulary size exceeds expressive vocabulary size because children with relatively poor attention toward a speaker benefit less from linguistic input than children with relatively good attention toward a speaker. And, logically, input processing deficits should affect receptive vocabulary prior to their effect on expressive vocabulary. At any point in time, this pattern should result in atypically small discrepancies between receptive and expressive vocabulary sizes. That is, for children with the same size of expressive vocabulary, those with low attention toward a speaker should have smaller receptive vocabulary sizes than children with relatively high attention toward a speaker. In contrast, oral motor theories posit that relatively poor oral motor performance tends to increase the gap between expressive and receptive vocabularies because, for children with the same receptive vocabulary size, those with relatively poor oral motor performance have difficulty in clearly speaking the words they understand and thus have relatively smaller expressive vocabulary sizes. This pattern results in atypically large discrepancies between receptive and expressive vocabulary sizes.

Attention Toward a Speaker

The speech attunement framework posits that children with ASD tend to have a reduced ability to "tune in" (i.e., attend to) and "tune up" to (i.e., broadly emulate the general characteristics of) others' speech (Schoen, Paul, & Chawarska, 2011; Shriberg, Paul, Black, & van Santen, 2011). This framework offers an input-processing deficit explanation for atypically small receptive–expressive vocabulary size discrepancies. The speech attunement framework emphasizes the need for the child to attend and respond to linguistic input from another individual to increase the accuracy and complexity of their vocalizations and verbalizations. As a group, children with ASD often present with deficits in attention to the speaker as indexed via a number of different measures and metrics, including conventionally coded and computer-analyzed eye gaze in response to videotaped and live vignettes, use of preferential looking paradigms, and other peripheral physiological measures (e.g., Chawarska et al., 2012; Chawarska, Macari, & Shic, 2013; Klin, 1991; Kuhl, Coffey-Corina, Padden, & Dawson, 2005; Watson, Roberts, Baranek, Mandulak, & Dalton, 2012). Available evidence suggests that attention toward a speaker could facilitate language development via enhanced learning from linguistic input. Documented benefits of visual access to the speaker, including but not limited to attention to the mouth, in individuals with typical development include better speech detection thresholds (Middelweerd & Plomp, 1987), increased speech perception accuracy (Davis & Kim, 2006; Schwartz, Berthommier, & Savariaux, 2004; Sumby & Pollack, 1954), and increased speech processing speed (Gilley, Sharma, Mitchell, & Dorman, 2010; van Wassenhove, Grant, & Poeppel, 2005). Further, attention toward a speaker has correlated positively with language development in children with and at risk for ASD (Chawarska et al., 2012; Norbury et al., 2009; Tenenbaum, Sobel, Sheinkopf, Malle, & Morgan, 2015; Watson, Barenek, Roberts, David, & Perryman, 2010; Young, Merin, Rogers, & Ozonoff, 2009). Measuring the degree to which children with ASD look toward the individual speaking (i.e., attention toward a speaker) may be one way to identify attention to linguistic input and to differentiate children with ASD with varying degrees of deviant language development.

Watson et al. (2010) developed a paradigm to test whether the proportion of time that young children with ASD looked toward short speaker vignettes correlated with concurrent and later language skills. In their sample of male children with ASD with language skills below a 24-month level, attention toward a speaker did correlate with receptive and expressive language skills as measured by a composite of the MB-CDI, MSEL, and Preschool Language Scale–Fourth Edition (Zimmerman, Steiner, & Pond, 2002) concurrently and 1 year later. Although these findings relate to the current question, Watson et al. (2010) did not examine whether variation in attention toward a speaker could explain the magnitude of receptive–expressive language discrepancies in children with ASD.

Deficits in attention to linguistic input might preclude, lessen, or eliminate the amount or quality of linguistic input that is the basis for receptive vocabulary development (Petersen & Posner, 2012). The effect of attention toward a speaker on receptive language is presumably earlier in the causal chain than its effect on expressive language, which is likely indirect. That is, primary effects that attention toward a speaker have on expressive language might occur indirectly through their effect on receptive development. Given that expression requires a number of operations that reception does not, correlations of attention toward a speaker and expressive vocabulary would likely be attenuated relative to correlations of attention toward a speaker and receptive vocabulary. For example, if children vary in their ability to access or pronounce the words they understand, then the number of different words they use in an interaction or test will vary even if they have the same receptive vocabulary size.

Oral Motor Performance

Theoretically, oral motor performance in children with ASD might predict receptive–expressive discrepancies in children with ASD due to the greater impact of oral motor deficits on expressive vocabulary than receptive vocabulary. For children with ASD with substantial oral motor deficits, one would predict receptive language skills notably above expectations based on expressive skills, resulting in atypically large receptive–expressive vocabulary size discrepancies.

Following reports of motor and imitation deficits in children with ASD, the dyspraxia and childhood apraxia of speech (CAS) hypotheses emerged early on as possible explanations for spoken language deficits in children with ASD (DeMyer, 1975; DeMyer et al., 1972; Douglas & Sanders, 1968). The dyspraxia hypothesis asserts that dyspraxia (i.e., a motor planning deficit) contributes to verbal and nonverbal communication (e.g., body language) deficits in children with ASD (DeMyer, 1975; DeMyer et al., 1972). More contemporary investigations continue to assess the degree to which CAS, which is a motor speech sound disorder that affects the "precision and consistency of movements underlying speech…in the absence of neuromuscular deficits" (e.g., muscle weakness; American Speech-Language-Hearing Association, 2007, p. 3), accounts for spoken language deficits in children with ASD. For instance, in 2015, Tierney and colleagues reported that 63.6% of children with ASD also have CAS.

In addition, a number of studies report deficits in oral motor performance for imitative and nonimitative movements in children with ASD (Belmonte et al., 2013; Gernsbacher et al., 2002; Gernsbacher, Sauer, Geye, Schweigert, & Hill Goldsmith, 2008; Thurm, Lord, Lee, & Newschaffer, 2007). Furthermore, correlations between oral motor performance and language skills have been identified. For example, Belmonte et al. (2013) reported that participants with impaired motor skills demonstrated atypically large receptive–expressive language discrepancies and poorer language growth relative to participants with more intact oral motor skills. Gernsbacher et al. (2002) reported that oral motor skills predicted whether children with ASD were nonverbal or fluent. Similarly, Thurm et al. (2007) identified parent report of whether the child with ASD imitated speech sounds as predictive of whether the child did or did not develop spoken language by 5 years of age. These findings demonstrate the potential for imitative and/or nonimitative oral motor performance to be informative to the present question of the typicality of receptive–expressive vocabulary size discrepancies in children with ASD.

Quantifying the Typicality of the Receptive–Expressive Vocabulary Size Discrepancy

To best serve the goal of identifying potential correlates of the vocabulary discrepancy in children with ASD, we need a metric of vocabulary that indexes the degree to which the discrepancy is atypically small or atypically large. That is, we need a metric to quantify the typicality, not just the magnitude, of the receptive–expressive vocabulary size discrepancy. As indicated above, some children with ASD are likely to have atypically small receptive–expressive vocabulary size discrepancies, whereas other children with ASD are likely to have atypically large discrepancies. To enable computation of within-child discrepancies of vocabulary size, we used a widely used vocabulary checklist (i.e., MacArthur–Bates Communicative Development Inventories [MB-CDI] Words and Gestures; Fenson et al., 2007) for both vocabulary modalities (i.e., reception and expression). To enable computation of the typicality of this discrepancy, we used the normative sample from this instrument. Compared with using intact group comparisons with smaller samples of children with typical development who are matched to children with ASD, using the data from the instrument's larger normative sample permitted more confidence in the reference values used to quantify typicality.

Research Questions

To evaluate potential predictors of the variation in the typicality of receptive–expressive vocabulary size discrepancies in children with ASD, we asked the following research question: Does (a) attention toward a speaker and/or (b) oral motor performance predict the typicality of receptive–expressive vocabulary size discrepancies 8 months later in children with ASD? No known studies have examined these longitudinal correlational associations, which have theoretical and clinical implications. Results indicating a positive correlation between the typicality of receptive–expressive vocabulary size discrepancies and attention to the speaker would be consistent with the speech attunement framework, an input-processing deficit explanation. Results indicating a positive correlation between the typicality of the receptive–expressive discrepancies and oral motor performance would be consistent with theories of oral motor deficits inhibiting language development in ASD, including the CAS-ASD hypothesis.

Method

Participants

Sixty-five (54 male and 11 female) children with ASD from a larger longitudinal correlational study on language development in initially preverbal children with ASD were included in the current study (Yoder, Watson, & Lambert, 2015). The larger study identified value-added predictors of receptive and expressive language development in children with ASD who were not yet using spoken words. Twenty-two other participants from the larger study were excluded due to missing data. No other participants from the initial study were excluded. As described in Yoder et al. (2015), inclusion criteria were (a) clinical diagnosis of ASD based on the Autism Diagnostic Observation Schedule (Lord et al., 2000) and the Diagnostic and Statistical Manual of Mental Disorders–Fourth Edition (Text Revision; American Psychiatric Association, 2000), (b) chronological age of 20–48 months, (c) use of no more than 20 different words per parent report, and (d) use of no more than five different word roots during a 15-min communication sample. Children with severe motor or sensory impairment or identified metabolic, progressive neurological or genetic syndromes were excluded from the larger study. At entry into the larger study, participants had a mean developmental ratio (i.e., mental age divided by chronological age × 100) of 36 (SD = 15) based on the Visual Reception, Fine Motor, Receptive Language, and Expressive Language subscales of the MSEL (Mullen, 1995). Developmental ratios are not available for time points after study entry.

In this report, data were drawn from measures administered 8, 12, and 16 months after the start of the larger study. Given the selection criteria for the larger study, expressive scores at early time points had too little variation to test the questions of interest. Table 1 presents participants' chronological age and vocabulary levels at the initiation and conclusion of the current study. Caregivers reported 49 participants to be White, 12 to be Black or African American, and four to be Asian. Three participants were reported to be Hispanic or Latino. The University of North Carolina at Chapel Hill and Vanderbilt University Institutional Review Boards approved study procedures. Caregivers provided written consent for participants.

Measures

Vocabulary

Primary caregivers completed the MB-CDI Words and Gestures form (Fenson et al., 2007), a vocabulary checklist, at the beginning, midpoint (i.e., 4 months postentry), and end point (i.e., 8 months postentry) of the current study (see Table 1). The Words and Gestures form was used because (a) it quantifies receptive and expressive vocabulary skills, rather than only expressive skills for the Words and Sentences form, and (b) the mean developmental level of the children with ASD at the end of the study was below 16 months, the ceiling age for which the Words and Gesture form was designed. Because this checklist uses the same list of words for receptive and expressive vocabulary performance, it permits a better estimate of the receptive–expressive vocabulary size discrepancy than a single measure or a pair of measures that use different words for receptive and expressive modalities. The raw score for "number of words understood and said" quantifies expressive vocabulary size. The raw score for "number of words understood" plus the raw score for "number of words understood and said" quantifies receptive vocabulary size. Subtracting each child's expressive vocabulary raw score from his or her receptive vocabulary raw score yields a receptive–expressive vocabulary size discrepancy. Because receptive raw scores must meet or exceed expressive raw scores on the MB-CDI, all receptive–expressive discrepancies are zero or positive with higher receptive than expressive vocabulary sizes.

To index the typicality of receptive–expressive vocabulary size discrepancies of the participants with ASD at the end point measurement period, we computed receptive–expressive discrepancy scores from 128 English-speaking 14-month-old children in the MB-CDI Wordbank (Frank et al., 2017). The Wordbank does not include participants with identified disabilities. We used the 14-month norms

Table 1. Participant characteristics.

Measure	Current study initiation				Current study end point (8 months postentry)			
	M	*SD*	Min	Max	*M*	*SD*	Min	Max
Chronological age (months)	43.46	7.16	32.16	56.02	51.36	7.15	40.31	63.57
MB-CDI Words Understood raw score	110	100	0	396	172	112	7	396
MB-CDI Words Said raw score	17	25	0	117	88	101	0	296
MB-CDI Words Understood age equivalency (months)	12.52	3.56	7.00	19.00	14.35	3.56	7.00	19.00
MB-CDI Words Said age equivalency (months)	13.48	2.99	9.00	19.00	14.74	3.95	9.00	19.00

Note. MB-CDI = MacArthur–Bates Communicative Development Inventories (Fenson et al., 2007).

because the average down-rounded age equivalency for the ASD sample at this study's end point was 14 months.

To index the eventual mediators used in the secondary analyses, expressive and receptive vocabulary raw scores were derived from the MB-CDI. These scores were derived from the midpoint measurement period.

Attention Toward a Speaker

Attention toward a speaker was measured at the initiation of this study using the protocol described in Watson et al. (2010) and Yoder et al. (2015). While the child sat at a table facing a puppet theater, female speakers presented three 1-min vignettes using child-directed speech. Two vignettes were videos: (a) a woman reads a children's picture book and (b) a woman plays with and describes a novel toy. The third vignette was a live puppet show. The child could see the speaker's face in all three vignettes. A small, inconspicuous video camera captured the child's face and eyes during the vignettes. From the video recordings, trained research assistants used a timed event behavior sampling method to code when the child was looking and not looking toward the theater window. The proportion of time the child looked toward the theater window that framed the speaker's face and referent (e.g., book or toy) or puppet out of the total time of the vignettes quantified attention toward a speaker. We used a proportion because vignettes varied slightly in length across participants. The mean length was 60.00 s (*SD* = 0.20 s) for the video book vignette, 66.02 s (*SD* = 7.39 s) for the live puppet show vignette, and 59.92 s (*SD* = 0.44 s) for the video toy vignette. Twelve percent of the sessions were coded for interobserver agreement without the primary coder knowing which sessions would be coded. For attention toward a speaker, the intraclass correlation coefficient using a two-way random model for absolute agreement was .98.

Oral Motor Performance

We assessed both imitative and nonimitative oral motor performance in an attempt to provide a more comprehensive assessment of oral motor skills. In contrast to nonimitative motor movements, to accurately imitate, a child must be able to not only perform the motor movement but also attend to another person's action (Rogers, Hepburn, Stackhouse, & Wehner, 2003; Stone, Ousley, & Littleford, 1997). Thus, motor skills and social responsivity are necessary for imitation. We included imitative and nonimitative oral motor tasks to provide insight into motor and social components for the oral motor tasks.

Trained research assistants administered a modified version of the Oral Motor Examination by Amato and Slavin (1998) to assess tongue, lip, and jaw movements at the first time point in this study. The measure was selected for use in the larger study because it (a) was the only measure in the literature that was specific to oral motor skills, not other early communicative skills, with empirical support as a correlate of expressive language in children with ASD (Amato & Slavin, 1998) and (b) measured imitative and nonimitative oral motor movements in children at the early stage of language development. Raw scores from the Eating Behaviors Scale (Amato & Slavin, 1998) quantify nonimitative oral motor skills. This scale assesses seven nonimitative oral motor behaviors (e.g., tongue lateralization, mandibular stability, and sucking) as 0 or 1 while the child eats a snack. For the Nonverbal Volitional Oral Abilities Scale (Amato & Slavin, 1998), participants are encouraged to imitate a variety of oral motor movements (e.g., tongue lateralization, lip puckering, and blowing raspberries). Raw scores from the 11 items scored 0, 1, or 2 on the Nonverbal Volitional Oral Abilities Scale quantify imitative oral motor skills.

Analytic Approach

Before addressing the primary research questions, we conducted a set of preliminary analyses to characterize the current sample of participants. Using the reference point from the typically developing children in the Wordbank, we generated typically developing referenced *z* scores ([discrepancy score for individual participant with ASD minus typically developing sample's mean discrepancy] / [typically developing sample's standard deviation for discrepancy]) for each child in the ASD group to index the typicality of the receptive–expressive vocabulary size discrepancies of the children with ASD. We then tested whether the mean receptive–expressive discrepancy was different from the typically developing comparison group via a one-sample *t* test with zero as the reference value.

To evaluate the primary research question of whether initial attention toward a speaker or initial oral motor skills predicted typicality of the receptive–expressive vocabulary size discrepancies 8 months later, we used a longitudinal correlational design and a linear regression model. Listwise deletion, instead of multiple imputation, was used to address missing data because attention toward a speaker was not correlated strongly with other variables in the sample. Multiple imputations are most effective in reducing bias when there are correlates of the variable with missing data (Enders, 2010). The assumptions for regression and correlation were tested. Unless otherwise stated, the data met assumptions of multivariate normality, heteroscedasticity, undue influence, and linearity. All analyses were completed with IBM SPSS Statistics Version 23 or Version 24.

Results

Preliminary Analyses

Table 2 displays the descriptive statistics for the analyzed variables. The degree of departure from the typical discrepancy is indicated in standard deviation units. Negative *z* scores indicate less-than-typical receptive–expressive vocabulary size discrepancies. For example, a *z* score of −1.00 indicates that the participant's receptive–expressive vocabulary size discrepancy is 1 *SD* less than is typical for children at the 14-month language level.

The participants with ASD exhibited a mean receptive–expressive discrepancy size *z* score of −0.46 ($SD = 1.09$, range −1.70 to 3.69) at the study end point, which is significantly below zero, $t(64) = -3.368$, $p = .001$. This finding indicates that the participants with ASD, on average, exhibited receptive–expressive vocabulary size discrepancies 0.46 *SD* smaller than the comparison group of typically developing 14-month-old children. In addition, the large standard deviations for attention toward a speaker and the imitative oral motor measures indicate sufficient variance to enable detecting an association with vocabulary discrepancy if present. In contrast, the standard deviation in the nonimitative oral motor measure (i.e., Eating Behaviors Scale) indicates limited variability.

Association Between Attention Toward a Speaker and Receptive–Expressive Vocabulary Size Discrepancy Typicality

Attention toward a speaker correlated positively with the typicality of receptive–expressive vocabulary size discrepancy 8 months later, $r(56) = .33$, $p = .01$ (see Figure 1). Participants who spent more time looking toward the vignettes tended to show larger discrepancies between their receptive and expressive vocabulary sizes. Said another way, participants with lower attention toward a speaker had a smaller receptive–expressive vocabulary size discrepancy.

Pertaining to the assumption of multivariate normality, the residuals of the association between attention toward a speaker and vocabulary discrepancy were positively skewed and overly kurtotic. In addition, we identified three participants with extremely high unstandardized residuals that formed a small second mode. These children are notable in Figure 1 because of their high receptive–expressive vocabulary discrepancy *z* scores. Primary caregivers reported that they used no spoken words but understood every word or almost every word on the MB-CDI. After removing participants from the small mode, the necessary multivariate normality assumption was met. The mean *z* score for receptive–expressive discrepancy was −0.59 ($SD = 0.74$, range −1.70 to 1.80), and the association between attention toward a speaker and receptive–expressive discrepancy was essentially the same as that reported above, $r(53) = .36$, $p < .01$.

Association Between Oral Motor Performance and Receptive–Expressive Vocabulary Size Discrepancy Typicality

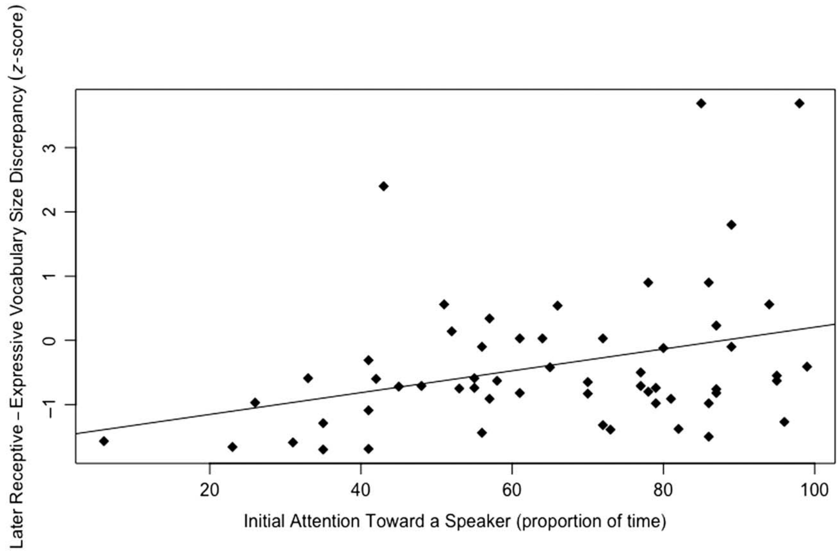
Imitative and nonimitative oral motor performance did not correlate significantly with the typicality of receptive–expressive vocabulary size discrepancy 8 months later, $r(59) = .10$, $p = .45$, and $r(59) = .09$, $p = .49$, respectively. Similar to the attention toward a speaker analysis, the residuals of the associations of receptive–expressive discrepancy and oral motor performance violated the multivariate

Table 2. Descriptive statistics of analyzed variables.

Variable	*M*	*SD*	Min	Max
Attention toward a speaker	0.65	0.22	0.06	0.99
Eating Behaviors Scale	6.10	1.21	3.00	7.00
Nonverbal Volitional Oral Abilities Scale	9.69	6.37	0.00	22.00
Receptive–expressive vocabulary size discrepancy *z* scores	−0.46	1.09	−1.70	3.69

Note. Receptive–expressive vocabulary size discrepancy *z* scores were calculated at the study end point. All other variables were collected at the study initiation. Attention toward a speaker is the proportion of time the child looked toward the theater window that framed the speaker's face and referent or puppet out of the total time of the vignettes. The Eating Behaviors Scale of the modified version of the Oral Motor Examination (Amato & Slavin, 1998) assesses seven nonimitative oral motor behaviors and ranges from 0 to 7. The Nonverbal Volitional Oral Abilities Scale of the modified Oral Motor Examination includes 11 oral motor imitation items, which yield scores from 0 to 22.

Figure 1. Longitudinal correlation between attention toward a speaker and receptive–expressive vocabulary size discrepancy 8 months later. Note that the three statistical outliers referenced in the text are depicted in order to represent the full range of variability in receptive–expressive vocabulary discrepancy typicality observed. Results were robust to removal of these participants.



normality assumption. After removing the participants from the small mode, the necessary multivariate normality assumption was met for both predictor variables. The results were essentially the same as those reported above for imitative oral motor performance, $r(56) = .14$, $p = .29$, and nonimitative oral motor performance, $r(55) = -.03$, $p = .84$.

Secondary Analyses

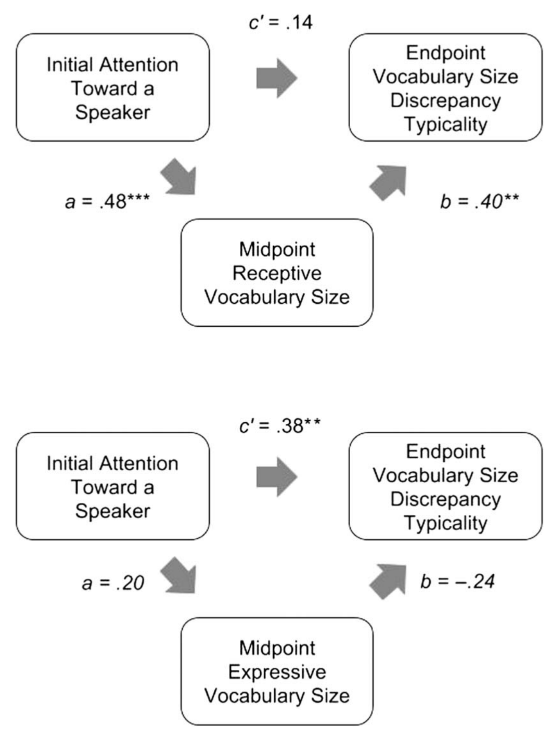
To further investigate the identified association between initial attention toward a speaker and end point receptive–expressive vocabulary size discrepancy typicality, we tested whether midpoint (i.e., 4 months postentry) receptive or expressive vocabulary size mediated this association. Theory suggested that receptive vocabulary size, but not expressive vocabulary size, might mediate the association of interest. A mediated relation is statistically significant when the confidence interval for the product of the unstandardized coefficients for the two associations comprising the indirect effect excludes zero (Hayes, 2013). Bias-corrected bootstrap confidence intervals were generated via 5,000 bootstrap samples. The confidence interval for the indirect effect of attention toward a speaker on receptive–expressive vocabulary size discrepancy typicality through midpoint receptive vocabulary size excluded zero and, therefore, is significant (unstandardized $a*b = .0106$, 95% CI [0.0031, 0.0232]; see Figure 2). This finding indicates that the association between attention toward a speaker and receptive–expressive vocabulary size discrepancy typicality was reduced significantly when controlling for midpoint receptive vocabulary size. Thus, the relation between attention toward a speaker and later receptive–expressive vocabulary size discrepancy was accounted for at least in part by the earlier association between attention toward a speaker and receptive vocabulary size. In contrast, the confidence interval for the indirect effect of attention toward a speaker on receptive–expressive vocabulary size discrepancy typicality through midpoint expressive vocabulary size included zero and, therefore, is nonsignificant (unstandardized $a*b = -.0023$, 95% CI [−0.0082, 0.0001]).

Discussion

The purpose of this study was to determine whether attention toward a speaker and oral motor performance predict the typicality of receptive–expressive vocabulary size discrepancies 8 months later in young children with ASD. Evaluating these associations is an early step toward determining why some children with ASD show a deviant, atypical language acquisition process as exhibited through their receptive–expressive vocabulary size discrepancies. The findings could inform our theoretical understanding of language development in children with ASD. Because attention toward a speaker and oral motor performance are likely to be more malleable than background variables, such as ASD symptomology severity, the findings could lead to interventions that more directly target mechanisms underlying deviant language development in children with ASD. Theoretical arguments suggest that atypically small receptive–expressive discrepancies would be associated with poorer attention toward a speaker and that atypically large discrepancies would be associated with reduced oral motor performance for children with ASD.

As a group, participants with ASD exhibited smaller receptive–expressive vocabulary size discrepancies than

Figure 2. Results for whether midpoint receptive or expressive vocabulary size mediates the association between initial attention toward a speaker and end point receptive–expressive vocabulary size discrepancy typicality. Displayed coefficients are standardized regression coefficients. **$p < .01$. ***$p < .001$.



children with typical development at the same vocabulary level. The children with ASD tended to exhibit comprehension of fewer words than expected relative to the number of words they said. These results are consistent with numerous published findings (e.g., Charman et al., 2003; Hudry et al., 2014, 2010; Kover et al., 2013; Luyster et al., 2008; Volden et al., 2011; Woynaroski, Yoder, & Watson, 2016). Examining the variability in the within-child vocabulary discrepancies provides additional insights into the receptive–expressive profiles of the participants. Attention toward a speaker measured 8 months prior to the study outcome predicted the typicality of this discrepancy. In contrast, neither imitative nor nonimitative oral motor performance predicted the typicality of receptive–expressive vocabulary size discrepancies. These findings are consistent with deviant language development in children with ASD. More specifically, they are consistent with the speech attunement framework for this atypicality rather than oral motor explanations such as the CAS-ASD hypothesis.

Attention Toward a Speaker Predicted Later Receptive–Expressive Vocabulary Size Discrepancy

As predicted by the speech attunement framework, children with ASD who showed relatively less attention toward a speaker tended to have less typical receptive–expressive discrepancies, characterized by unexpectedly small receptive vocabulary sizes for their expressive vocabulary sizes. The participants present with different relative receptive and expressive vocabulary sizes than children with typical development at the same overall language level. Furthermore, variation in receptive vocabulary size, not expressive vocabulary size, mediated the association between initial attention toward a speaker and end point receptive–expressive vocabulary size discrepancy typicality. These findings are consistent with deficits in receptive vocabulary being partly responsible for the association of interest (i.e., the association of attention toward a speaker and receptive–expressive vocabulary size discrepancy typicality). Thus, these findings are consistent with an input-processing deficit explanation for the discrepancy.

One possible explanation is that, in toddlers and preschoolers with ASD, deficits in attention toward a speaker slow the trajectory of receptive vocabulary growth more than that of expressive vocabulary growth. Consequently, their discrepancies between receptive and expressive skills are narrowed compared with those of children with typical development at the same language level. The attention toward a speaker variable could index one or both of two generalized behavioral tendencies: auditory attention to input and visual attention to the visible cues on the speaker's face that enhance auditory processing of input. Looking toward a speaker (particularly the mouth) might enable listeners to take advantage of visual cues that combine synergistically with auditory cues to facilitate speech processing. This explanation aligns with previously reported positive correlations between attention to child-directed speech and language for children with ASD (Kuhl et al., 2005; Paul, Chawarska, Fowler, Cicchetti, & Volkmar, 2007; Watson et al., 2010). It also aligns with correlations between attention to the mouth, eye gaze, or referent and language skills (Tenenbaum, Amso, Righi, & Sheinkopf, 2017; Tenenbaum et al., 2015; Young et al., 2009) and faster and more accurate speech processing and/or perception in the presence of visual cues for individuals without ASD (Davis & Kim, 2006; Gilley et al., 2010; Schwartz et al., 2004; Sumby & Pollack, 1954; van Wassenhove et al., 2005). Relatively poor attention toward a speaker may disrupt language development with one manifestation being unexpectedly low receptive language abilities relative to the child's expressive abilities.

Oral Motor Skills Did Not Predict Later Receptive–Expressive Vocabulary Size Discrepancy

Neither imitative nor nonimitative oral motor performance predicted the typicality of receptive–expressive vocabulary size discrepancy 8 months later. Correlations between oral motor performance and vocabulary discrepancy size were weak. These findings do not support the assertion that children with ASD as a group tend to present with deficits in spoken language due to oral motor planning deficits as proposed by the dyspraxia hypothesis and the CAS-ASD hypothesis. Neither oral motor functioning measure correlated with the typicality of receptive–expressive vocabulary size discrepancies. The participants on average demonstrated smaller, not larger, than expected receptive–expressive vocabulary size discrepancies. Nonetheless, some of these children, albeit a small minority, had larger than expected receptive–expressive vocabulary size discrepancies.

Nonsignificant findings may occur when an analysis is underpowered, measures do not sufficiently capture the constructs of interest, and/or the underlying theory is inaccurate. Given the low correlations between the receptive–expressive discrepancy and oral motor performance, it is unlikely that low power is the only reason for the nonsignificant findings. In general, a restricted range of values on a measure limits the ability to observe a correlation between that measure and another variable. In this study, participants scored across the full range on the imitative oral motor measure, but within a limited range on the nonimitative oral motor measure (i.e., Eating Behaviors Scale). On this 0–7 scale, which was the only known measure of nonimitative oral motor skills for children with ASD at the developmental level of the study's participants, many participants scored 6 or 7, and none scored below 3. Although this reduced range influences one's ability to observe a correlation with another variable, it also indicates that few participants demonstrated difficulty in completing the tasks. A nonimitative oral motor performance deficit at most could explain spoken language deficits for a small portion of children with ASD. If the study sample had been selected specifically for children with atypically large vocabulary size discrepancies, it is possible that nonimitative oral motor performance would correlate with the discrepancy size. Future work is needed to address that hypothesis.

Participants' performance on the oral motor tasks combined with the lack of significant correlations and atypically small, not atypically large receptive–expressive vocabulary size discrepancies suggest that the underlying theory may require revision. Consistent with our findings, other studies have reported intact oral motor ability without signs of CAS (Shriberg et al., 2011) and largely intact articulation skills (Kjelgaard & Tager-Flusberg, 2001; Tager-Flusberg, Paul, & Lord, 2005) in children with ASD.

Limitations

Four limitations should be acknowledged. First, we used a longitudinal correlational design for the primary analyses. We cannot rule out all third variable explanations for the identified association. Second, our study sample might not fully represent the population of toddlers and preschoolers with ASD. For example, participants presented with cognitive impairment, on average, which does not characterize the entire population of children with ASD. Future studies are required to determine whether the current findings apply to children with ASD with a broader range of expressive language and cognitive abilities. Third, this study did not include a comparison condition that provided adult-directed speech rather than child-directed speech. Thus, the construct indexed may be either attention toward a speaker or attention to child-directed speech. Future research should address whether the atypically small receptive–expressive vocabulary size discrepancy is due to a deficit in attention toward a speaker in general or only attention toward a speaker who is using child-directed speech. Fourth, the measure of attention toward a speaker coded the amount of time looking toward the theater window. We do not know to which part of this area, including the speaker's mouth versus eyes, the face more broadly speaking, or even other relevant aspects of the complex communicative scene (such as the referent of the adult talk), the child visually attended.

Strengths

Three strengths of the study are noteworthy. First, the study design permits investigation of within-child discrepancies in receptive–expressive vocabulary sizes. In contrast, most prior studies were restricted to between–diagnostic–groups differences in the receptive–expressive profiles. Furthermore, indexing the receptive–expressive vocabulary discrepancy of children with ASD in the current study to those found in the vocabulary measure's normative database enabled assessing whether vocabulary discrepancies were atypical and whether the average discrepancy was larger or smaller than is seen in children with typical development at the same language level. Second, the predictors are theoretically motivated and potentially malleable. These characteristics increase the likelihood that they can impact intervention practices in a meaningful way with sufficient investigation. Third, longitudinal correlational evidence provides stronger support for the possibility that variation in attention toward a speaker influences variation in the receptive–expressive vocabulary discrepancies than concurrent evidence. Although neither longitudinal correlational or concurrent correlational studies eliminate all third variable explanations required for making causal inferences, the former meets the causal principle of measuring the putative cause prior to the putative effect, but the latter does not.

Future Research and Clinical Implications

The potentially malleable nature of attention toward a speaker has important implications for future research and possible implications for intervention. Precisely where a child with ASD looks when others are speaking to him or her might influence gains during intervention. During certain stages of language development, but not others, infants with typical development look relatively more toward speakers' mouths than eyes (e.g., around the time of the emergence of canonical babbling; Frank, Vul, & Saxe, 2012; Lewkowicz, & Hansen-Tift, 2012; Nakano et al., 2010). For children with ASD, looking at the mouth more than the eyes might facilitate strong positive effects at one language development stage, yet yield null or even negative effects at others. The measure of attention toward a speaker used in the current study did not permit examination of specific regions of interest to which the child attended, and these hypotheses warrant further investigation in children with ASD. Only one known study attempts to increase the amount of time children with ASD look toward relevant sources of information—the speaker's mouth and the target object. For a receptive word learning task with young school-age children with ASD (M = 69.76 months), Tenenbaum et al. (2017) found that holding the target object near the speaker's face improved word learning performance relative to holding the object farther away from or in front of the speaker's mouth. In contrast, pointing to the speaker's mouth while holding the object farther away decreased performance relative to a condition without pointing. Other studies have assessed attention to the face, including attention to the mouth, specifically in individuals with ASD (e.g., Klin, Jones, Schultz, Volkmar, & Cohen, 2002; Nakano et al., 2010; Tenenbaum, Amso, Abar, & Sheinkopf, 2014; Tenenbaum, Shah, Sobel, Malle, & Morgan, 2013; Tenenbaum et al., 2015), but have not attempted to actively manipulate attention as Tenenbaum and colleagues (2017) did. Future studies should evaluate the degree to which intervention targeting attention toward a speaker affects generalized vocabulary and broader spoken language outcomes, and the mechanisms by which it may do so, in children with ASD.

Conclusion

Neither imitative nor nonimitative oral motor skills predicted the magnitude of receptive–expressive vocabulary size discrepancies in young children with ASD. Furthermore, oral motor theories of language development in children with ASD predict larger receptive–expressive vocabulary size discrepancies, not the smaller discrepancies that characterized most of the children in this study sample. Thus, the present results are not consistent with theories of oral motor deficits resulting in atypical receptive–expressive discrepancies in children with ASD. In contrast, individual variation in attention toward a speaker might explain, in part, variation in the magnitude of receptive–expressive vocabulary size discrepancies in children with ASD. In addition, midpoint receptive vocabulary size was found to at least partially explain the association between initial attention toward a speaker and later receptive–expressive vocabulary size discrepancy typicality. Findings are consistent with the speech attunement framework, which offers an input-processing deficit explanation for receptive–expressive vocabulary size discrepancies in children with ASD. Given the relation between attention toward a speaker and degree of receptive–expressive discrepancy typicality as well as the potential malleability of attention toward a speaker, it could be an effective treatment target. Future research should test the malleability of attention toward a speaker and its influence on language development in children with ASD through internally valid intervention studies.

Acknowledgments

This research was funded by a grant from the National Institute on Deafness and Other Communication Disorders (R01DC006893; Vanderbilt University) and further supported by a U.S. Department of Education Preparation of Leadership Personnel grant (H325D140087; Vanderbilt University), the EKS of NIH (U54HD083211; Vanderbilt University), the National Center for Advancing Translational Sciences (KL2TR000446; Vanderbilt University), and the National Institute of Child Health and Human Development (P30HD03110; University of North Carolina at Chapel Hill). We are grateful to the families who trust us with their precious children.

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