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A Discrepancy in Comprehension and Production in Early Language Development in ASD: Is it Clinically Relevant?

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Abstract

This study examined the extent to which a discrepant comprehension-production profile (i.e., relatively more delayed comprehension than production) is characteristic of the early language phenotype in autism spectrum disorders (ASD) and tracked the developmental progression of the profile. Our findings indicated that a discrepant comprehension-production profile distinguished toddlers (30 months) with ASD from late talkers without ASD (91% sensitivity, 100% specificity) in groups that were comparable on expressive language, age, and socioeconomic status. Longitudinal data for children with ASD revealed that the discrepant profile steadily decreased from 30 to 44 months until there was no significant comprehension-production difference at 66 months. In conclusion, results suggest that lower comprehension than production may be an age-specific marker of toddlers with ASD.

Keywords

autism spectrum disorder; comprehension; production; language; late talker

Children with autism spectrum disorders (ASD) often present with a discrepant comprehension-production language profile—a relative degree of delay that is more pronounced for comprehension than production (i.e., higher production than comprehension performance) (Barbaro and Dissanayake 2012; Barneveld et al. 2014; Charman et al. 2003; Ellis Weismer et al. 2010; Hudry et al. 2010; Kover et al. 2013; Loucas et al. 2008; Luyster

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Compliance with Ethical Standards

Ethical Approval: All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments.

Informed Consent: Informed consent was obtained from the parents or legal guardians of all participants included in the study.

et al. 2008; Maljaars et al. 2012; Seol et al. 2014; Volden et al. 2011). More children with ASD show the discrepant comprehension-production profile than typically developing (TD) children or children with other developmental and intellectual disabilities (Barbaro and Dissanayake 2012; Ellis Weismer et al. 2010; Maljaars et al. 2012; Seol et al. 2014). In a sample of children matched on nonverbal cognition, discrepant comprehension-production profiles were found in 31% of children with autistic disorder and intellectual disability, 24% of children with intellectual disability, and 15% of TD children (Maljaars et al. 2012). Seol et al. (2014) reported that 43% of children with ASD had a discrepant comprehension-production profile whereas 11% of children with language delays without ASD had a relative receptive language weakness. Ellis Weismer et al. (2010) did not characterize their sample in terms of percentages, but found that expressive language was significantly higher than receptive language on two of three language measures for toddlers with autistic disorder whereas the toddlers with PDD-NOS or a developmental delay (DD) displayed more equivalent patterns of comprehension and production abilities.

While most group comparisons have found higher percentages of relative comprehension weakness in children with ASD (with or without concomitant intellectual disability), Luyster and colleagues (2007) did not find significant differences in comprehension-production abilities in children with ASD (30 months) when compared to children with developmental delay (DD; 26 months) or TD controls (18 months) who were matched on nonverbal mental age. It is notable that the DD and TD comparison groups were younger than the ASD group, and this may have contributed to the lack of group differences in comprehension-production performance because when the ASD group was compared to age-mates from the norming sample on a standardized measure, children with ASD did show a relative expressive advantage over receptive language.

Similarly, other studies comparing the ASD group's performance to the normative sample from standardized measures report relative comprehension weaknesses. These findings were based on statistical comparison of language domains across receptive-expressive subtests/ tests (Barbaro and Dissanayake 2012; Barneveld et al. 2014; Hudry et al. 2010; Kjelgaard and Tager-Flusberg 2001; Kover et al. 2013; Luyster et al. 2008), analysis of difference/ discrepancy scores (Loucas et al. 2008; Pickles et al. 2014; Volden et al. 2011), or visual examination of graphed data for vocabulary (Charman et al. 2003; Hudry et al. 2010), see Table 1. Other researchers have categorized children according to their language domain profile. For example, Seol et al. (2014) identified children as expressive dominant, receptive dominant, or non-dominant and examined the frequency of these profiles relative to comparison groups. Only two prior studies have addressed the issue of meaningful differences in scores (Kjelgaard and Tager-Flusberg 2001; Kover et al. 2013). As summarized in Table 1, a variety of terminology has been used in this literature to describe the observed language profile including 'atypical,' 'expressive language advantage,' 'discrepancy/difference,' and 'relative impairment in comprehension.'

Equivalent receptive and expressive language abilities have been reported for samples of older children and adolescents with ASD ranging from 9-14 years (Loucas et al. 2008), 4-14 years (Kjelgaard and Tager-Flusberg 2001), and 5.5-19.6 years (Jarrold et al. 1997). Loucas et al. (2008) compared performance of children with ASD with language impairment, ASD

without language impairment, and children with specific language impairment (SLI). No significant group differences were found using two separate tests of receptive and expressive language. Jarrold et al. (1997) also reported no discrepant comprehension-production profile in children with ASD using separate tests of receptive or expressive language. The study by Kjelgaard and Tager-Flusberg (2001) reported mixed results; there was not a difference score of more than one standard deviation on receptive-expressive vocabulary but a receptive-expressive discrepancy was found on an omnibus language test tapping semantics, morphology and syntax (though the 1 SD clinically meaningful criterion was not used for the later comparison).

For the most part, the type of assessment instruments that have been used to examine the comprehension-production profile in children with ASD do not appear to play a role in variations in the results. Studies that have reported relative comprehension weaknesses compared to production have employed a variety of standardized, clinician administered tests (e.g., Ellis Weismer et al. 2010; Luyster et al. 2008; Volden et al. 2011) as well as parent report measures (e.g., Charman et al. 2003; Luyster et al. 2007). It is worth noting, however, that a specific parent report measure, the Vineland, appears to yield different early profiles than other language measures (perhaps because it focuses broadly on communication rather than just language). In fact, two studies that found relative comprehension weakness in toddlers with ASD using other language measures reported the opposite profile (i.e., comprehension advantage over production) in the same groups of children when using the Vineland (Ellis Weismer et al. 2010; Luyster et al. 2008).

Despite numerous findings of a discrepant comprehension-production profile in ASD, a recent meta-analysis examining comprehension and production in children and adolescents with ASD reported no evidence of comprehension weakness compared to production (Kwok et al. 2015). There are a number of reasons, however, to question this conclusion. The study by Kwok et al. described investigations that focused on comprehension-production profiles but did not include most of them in the actual meta-analysis. Instead, the meta-analysis consisted primarily of studies examining other topics, which is not a problem in and of itself. However, for those studies that included a TD comparison group the matching criteria were not taken into account and when the ASD group's performance was compared to a normative sample (in cases without a TD comparison group) the measures of receptive and expressive language were not necessarily derived from subtests of a single test or tests that were co-normed. Additionally, the analysis of age/developmental effects on language comprehension-production profiles was conducted at such a gross level (1-5 years vs. 6-20 years) that different patterns across development may well have cancelled out each other.

Only a handful of studies have explored the development of the pattern of comprehension-production abilities in children with ASD. With respect to *changes* in comprehension-production profiles over time, one investigation examined the development of expressive and receptive language in toddlers with developmental/language delays (D/LD), autistic disorder (AD), and broader ASD at 18 and 24 months (Barbaro and Dissanayake 2012). A discrepant comprehension-production profile was found in all three groups at 18 months such that there was a relative receptive language weakness. At 24 months, a discrepant comprehension-production profile was apparent in the AD and broader ASD groups but not D/LD group. All

three groups' receptive language improved during this developmental period, but the D/LD group made three times more gains than the AD group and two times more gains than the broader ASD group. These results suggest that while a relative comprehension weakness may be apparent early in development (i.e., at or before 18 months) for children with D/LD, developmental gains, especially in receptive language abilities, leads to the disappearance of the profile by 24 months. A recent study by Woynaroski et al. (2016) examined age equivalence scores from a parent-report measure of receptive and expressive vocabulary (CDI) in minimally verbal children with ASD. Language abilities were assessed at four time points, beginning when the children were 24 to 48 months of age. Results indicated that expressive age equivalent scores were higher than receptive at all four periods and cross-lagged correlational analyses suggested that expressive vocabulary may drive development of receptive vocabulary in preschoolers with ASD who are minimally verbal. In a longitudinal study covering a wide span of development, Pickles et al. (2014) used the Vineland to examine changes in comprehension-production profiles in children with ASD from 2- to 19-years. Findings from that study indicated that a pattern of relative receptive language weakness compared to expressive language occurred later in development rather than earlier in development. However, as noted above this result may have been influenced by the specific measure used to assess language abilities.

A cross-sectional study focused on toddlers and preschoolers found that a discrepant comprehension-production profile persisted until 30-39 months for children with ASD (Seol et al. 2014). Specifically, Seol et al. (2014) found a 'receptive dominant' profile in 55.6% and 54.1% of children with ASD at 20-29 months and 30-39 months, respectively, but the percent of individuals with a discrepant comprehension-production profile decreased to 23.1% at 40-49 months with most children showing neither a receptive nor expressive advantage at that age. Together, the longitudinal and cross-sectional evidence suggest that a relative pattern of comprehension weakness in children with ASD persists longer than in other children with D/LD and begins to disappear around 40-49 months. However, a longitudinal examination of comprehension-production profiles using a comprehensive measure designed to specifically evaluate language comprehension and production abilities during this early period is necessary to determine the true developmental nature and significance of this profile.

In summary, there is considerable evidence that, as a group, children with ASD are more likely to display a discrepant comprehension-production profile than typically developing children (e.g., Hudry et al. 2010; Kover et al. 2013; Volden et al. 2011) or those with developmental/intellectual disabilities or language delay (e.g., Barbaro and Dissanayake 2012; Maljaars et al. 2012). One comparison group that has not been investigated are so-called 'Late Talkers' (LTs) who have late onset of language development without other developmental concerns (Hawa and Spanoudis 2014; Rescorla and Dale 2013). There are several reasons that comparison of language profiles in LT toddlers and toddlers with ASD may be of interest. Given the research focused on possible overlaps in language profiles between children with ASD and those with SLI (Haebig et al. 2015; Loukusa et al. 2014; McGregor et al. 2012; Norbury 2005; Whitehouse et al. 2007), insights regarding initial stages of this potential overlap could be gained by studying LTs who are at risk for SLI (Ellis Weismer 2007). Because SLI is not diagnosed until later in the preschool period

(Tager-Flusberg and Cooper 1999), it is necessary to consider an at-risk population in order to investigate early periods of development. There is also clinical motivation to consider this comparison. Delayed language production is characteristic of both children with ASD (Boucher 2012) and LTs (Hawa and Spanoudis 2014). In fact, delayed language is often a primary reason families seek developmental evaluations for their child (Guinchat et al. 2012; Reiner Hess and Landa 2012). It is not always clear how to clinically distinguish toddlers with less overt symptoms of ASD from young children with language delays only (Camarata 2014; Paul and Ellis Weismer 2013). Comparison of the comprehension-production profiles in LTs and toddlers with ASD could assist with appropriate referrals and early differential diagnosis. Finally, as noted above, there is scant information about how the relation between language comprehension-production domains changes over development in children with ASD. The present study contributes to the literature by addressing these issues.

Our first research question addressed the sensitivity and specificity of a comprehension weakness compared to production for 30-month-old LT and ASD toddlers because this is the age when many families seek developmental evaluations for their children (Guinchat et al. 2012). We predicted that a discrepant comprehension-production profile would be found more frequently in the ASD group relative to the LT group, and with the increased frequency of occurrence in the ASD group, we expected this to be a sensitive and specific marker of language patterns in toddlers with ASD compared to LT. Our second research question examined the developmental progression of comprehension-production profiles in children with ASD at pre-determined time points from a longitudinal investigation (30, 44, and 66 months). We expected that the frequency of the discrepant comprehension-production profile would decline in the same group of children followed over time.

Methods

Participants

LT and ASD children were drawn from two longitudinal projects examining early language development in children during the preschool period (see Davidson and Ellis Weismer 2014; Ellis Weismer, Gernsbacher, et al. 2011; Ellis Weismer, Venker, et al. 2011; Ellis Weismer and Kover 2015; Moyle et al. 2007; Venker et al. 2014 for previous studies including participants from these projects). Both groups of children completed comparable language and cognitive evaluations at approximately 30 months of age, which are the focus of the first research question in this study. For the second research question, we included children with ASD who had complete longitudinal data available at mean ages 30, 44, and 66 months for a variety of language, cognitive, and autism assessment measures.

Children were recruited from the state of Wisconsin through multiple sources including a research birth registry, early intervention providers, clinics, and the general community via posted fliers. Exclusionary criteria for both groups included known chromosomal abnormalities, cerebral palsy, frank neurological insult, uncorrected vision or hearing impairments, prematurity, multiple birth, bilingualism, and seizure disorder. The university Institutional Review Board approved this research and all parents provided written consent for their child's participation.

To address our first research question, we selected a total of 64 LT and ASD children with comparable ages, maternal levels of education, and expressive language abilities (see Table 2). Participants with ASD ($n = 32$; 84% male; 75% white) received comprehensive autism diagnostic evaluations at approximately 30 months by clinicians (psychologists and speech-language pathologists) who were experienced in assessing autism spectrum disorders and language delay. Specifically, we determined autism characteristics and diagnoses using a combination of the toddler research version of the *Autism Diagnostic Interview, Revised* (ADI-R; Rutter, Le Couteur, et al. 2003), the *Autism Diagnostic Observation Schedule* (ADOS; Lord et al. 2002), or the ADOS, toddler version (ADOS-T; Luyster et al. 2009) and expert clinical judgment in line with the *Diagnostics Statistical Manual of Mental Disorders, Fourth Edition, Text Revised* (DSM-IV-TR) criteria (American Psychiatric Association 2000). The ADI-R uses a semi-structured parent interview to determine the child's qualities of reciprocal social interaction, communication and language, and restricted and repetitive, stereotyped interests and behaviors in everyday circumstances. The ADOS assesses these same characteristics during a single time point in a semi-structured, observational assessment. Calibrated autism severity scores were calculated from the raw scores on the ADOS/ADOS-T (Gotham et al. 2009).

LT participants ($n = 32$; 69% male; 94% white) were administered the McArthur-Bates Communication Development Inventory (CDI) Words and Sentences form (Fenson et al. 2007) at 24 months in order to assign group membership based on language production abilities. There are numerous published studies of late talkers that have relied solely on the CDI, a norm-referenced parent report measure, to identify and characterize this group (Fernald and Marchman 2012; Jones and Smith 2005; Petrucci et al. 2012), using varying cutoff points ranging from below the 5th percentile at the lowest end (Girolametto et al. 1997) to the 20th percentile (Fernald and Marchman 2012; Jones and Smith 2005). In the longitudinal project from which we drew the LT data, we identified LT status using a 10th percentile cutoff on the CDI at 24 months. Prior research investigating late onset of language has also used this criterion (Robertson and Ellis Weismer 1999; Thal et al. 1997). We then conducted comprehensive language and cognitive assessments in the lab starting at 30 months. While the majority of children continued to meet the LT 10th percentile cutoff on the CDI at 30 months, a substantial proportion (41%) were late bloomers who were starting to catch up (operationally defined as a CDI score >10th percentile and PLS production standard score >85). At 66 months of age, we confirmed that none of the LT children met criteria on the Social Communication Questionnaire (Rutter, Bailey, et al. 2003) and that none of the LTs had received an ASD diagnosis from their communities at any point in development.

For our second research question, we selected a larger sample of children with ASD ($n = 81$; 90% male; 86% white) who had receptive and expressive language scores available at 30, 44, and 66 months. See Table 3 for a summary of ASD group characteristics for the longitudinal data. The selected participants did not differ from the unselected participants ($n = 39$) at Time 1 in independent sample t-tests for age ($t(118) = 0.72, p = .473, d_{Cohen} = 0.14$), socioeconomic status (SES) as indicated by mother's years of education ($t(117) = 0.60, p = .548, d_{Cohen} = 0.11$), nonverbal cognition ($t(117) = -0.45, p = .656, d_{Cohen} = -0.09$), autism severity ($t(118) = 0.79, p = .429, d_{Cohen} = 0.14$), receptive language abilities

($t(116) = 0.14, p = .886, d_{Cohen} = 0.03$), or expressive language abilities ($t(115) = 1.71, p = .090, d_{Cohen} = 0.34$).

We conducted annual reassessments for ASD during clinic visits and all children reported in the study maintained their ASD diagnosis at each visit. Given the time frame of the longitudinal investigation DSM-IV-TR criteria were used rather than DSM-5 criteria. Parents of children with ASD reported that 67% of these participants received intensive autism treatment during some or all of the study.

Briefly, to aid in the interpretation of our results, we compared the descriptive statistics of our selected samples. The sample for research question 2 included 19 participants from the ASD group whose data were included in research question 1. The participants who were ($n = 19$) or were not ($n = 13$) included in the sample for research question 2 did not significantly differ for age, SES, nonverbal cognition, autism severity, receptive language, or expressive language ($ps > .162$). The ASD participants included in research question 1, as a whole ($n = 32$), differed from the other participants included in research question 2 ($n = 62$) in that the participants included in research question 1 had higher nonverbal cognition ($t(91) = -3.72, p < .001, d_{Cohen} = -0.81$), receptive language ($t(92) = -2.83, p = .006, d_{Cohen} = -0.62$), and expressive language ($t(92) = -11.23, p < .001, d_{Cohen} = -2.44$) than the remaining participants included in research question 2. These groups of participants did not differ in age ($t(92) = -0.13, p = .897, d_{Cohen} = -0.03$), SES ($t(92) = -1.64, p = .105, d_{Cohen} = -0.36$), or autism severity ($t(92) = 0.16, p = .873, d_{Cohen} = 0.03$). These comparisons suggest that the subsample of participants compared to the LT group may be considered higher functioning on average; although, it is notable that both samples incorporated a wide range of abilities.

Measures

We used the Auditory Comprehension (AC) and Expressive Communication (EC) standard scores ($M = 100, SD = 15$) from the *Preschool Language Scale, Third Edition* (PLS-3; Zimmerman et al. 1992) for the LT children or *Fourth Edition* (PLS-4; Zimmerman et al. 2002) for the ASD children to characterize the language profile. Specifically, we calculated a difference score by subtracting the EC standard score from the AC standard score (i.e., Difference Score = AC – EC). In this way, negative values indicate a discrepant comprehension-production profile, where production is higher than comprehension.

For Question 1, we assessed nonverbal cognition at 30 months using the *Bayley Scales of Infant Development, Second Edition* (Bayley-II; Bayley 1993) for the LT children or *Third Edition* (Bayley-III; Bayley 2006) for the children with ASD. For the LT group, only the 11 nonverbal items were administered. Therefore, as in previous studies (Ellis Weismer, Gernsbacher, et al. 2011; Moyle et al. 2007), we used the raw scores based on these items as an indicator of nonverbal cognitive abilities in both groups. For descriptive purposes, we report the Bayley-III nonverbal ratio IQ at 30 months and the *Mullen Early Scales of Learning* (Mullen 1995) nonverbal ratio IQ at 44 and 66 months for ASD participants included in Question 2. The nonverbal ratio IQ score has previously been used and validated in this population (Bishop et al. 2011; Davidson and Ellis Weismer 2014; Rogers et al. 2003).

Analysis Plan

Data were evaluated for non-normality. Distributions were visually inspected and were considered not severely different from normality if the standardized skewness and kurtosis values were less than 1.96 (Field 2013). Transformations, removal of outliers, and non-parametric analyses were then considered.

For the first research question, matching tightly within a narrow age range resulted in a severely non-normal distribution; therefore, we employed a non-parametric Independent Samples Mann-Whitney U test to confirm that the LT and ASD groups were matched on this measure. In addition, we identified the distributions as non-normal for the comprehension scores in the ASD group and the comprehension-production difference scores in both groups. To correct for non-normality for the comprehension scores, we removed two outliers in the ASD group who had higher comprehension scores than the remaining participants. We then applied a log (base 10) transformation to the participant scores in both groups, which resulted in adequately normal distributions. To correct for non-normality for the comprehension-production difference scores, one participant from each group with the highest positive difference score was removed. Results for the full sample were comparable to the results of the analyses with outliers removed and transformations applied; for complete transparency, both approaches are reported in the results.

For the second research question, we followed a similar approach. Again, the comprehension scores and the comprehension-production difference scores were identified as non-normal. The distributions varied in normality over time; therefore, the same transformation and outliers could not be applied across time. To address the issues of non-normality, we applied both parametric and non-parametric analyses, as described below, for these measures, which indicated equivalent results.

To address the first research question, we examined the group differences for comprehension-production scores for the LT and ASD groups using analysis of variance (ANOVA). Second, given that the two groups differed in nonverbal cognition, we examined the group differences for comprehension-production scores again while controlling for nonverbal cognition using analysis of covariance (ANCOVA) as well as examining whether there was an interaction between group and nonverbal cognition.

To further characterize the group differences with respect to comprehension-production profiles, we categorized the children in each group based on whether the difference score was a meaningful difference or not. Specifically, as Kover et al. (2013) pointed out, a “meaningful” difference score accounts for differences beyond measurement error. We adapted this approach by determining whether a score was beyond the standard error of measurement at the 95% confidence interval for the child’s chronological age as defined in the PLS-4 manual. Based on our categorizations and given that some cells had less than 5 participants, we used a two-tailed Fisher’s exact test to determine whether the proportion of children with a meaningful comprehension-production profile was statistically different across groups.

Next, we determined the sensitivity and specificity of the meaningful comprehension-production profiles for the ASD and LT groups. Sensitivity is the number of true positives (TP) divided by the sum of true positives and false negatives (FN), or $\text{Sensitivity} = \text{TP}/(\text{TP} + \text{FN})$. Specificity is the number of true negatives (TN) divided by the sum of true negatives and false positives, or $\text{Specificity} = \text{TN}/(\text{TN} + \text{FP})$. For these comparisons, children were classified as follows: TP = ASD children with a discrepant meaningful comprehension-production profile, FN = ASD children who did not have a discrepant profile, FP = LT children with a discrepant profile, and TN = LT children who did not have a discrepant profile. To calculate the odds ratio, we used an online calculator available at https://www.medcalc.org/calc/odds_ratio.php.

With regard to the second research question, we employed a one-way repeated-measures ANOVA and a Friedman's ANOVA to evaluate language difference scores, with paired samples t-tests and Wilcoxon signed-rank tests to assess differences at each time point. As an alternative to the analysis of difference scores, we also conducted a two-way repeated-measures ANOVA with Time and Language Domain as within-subjects effects. Wilcoxon Signed-Rank tests were also conducted to assess the Language Domain differences at each Time. Effect sizes respective to each analysis approach were calculated using r , Cohen's d , or partial eta squared (η_p^2) values.

Results

Table 2 provides a summary of LT and ASD group characteristics for research question 1. Respective effect sizes for group comparisons indicated small and no significant differences between the ASD and LT groups for chronological age ($U = 504.00$, $z = -0.11$, $p = .909$, $r = -0.01$), SES ($t(62) = .45$, $p = .656$, $d_{\text{Cohen}} = -.11$), and expressive language abilities ($t(62) = 1.72$, $p = .090$, $d_{\text{Cohen}} = -.43$). However, there were large and significant group differences for nonverbal cognition ($t(62) = 7.34$, $p < .001$, $d_{\text{Cohen}} = -1.83$) and receptive language abilities (full sample: $t(62) = 11.60$, $p < .001$, $d_{\text{Cohen}} = -2.90$); outliers removed and log-transformed: $t(60) = 14.83$, $p < .001$, $d_{\text{Cohen}} = -3.66$).

Next, we compared comprehension-production difference scores for each group, and found a large and significant main effect of group (full sample: $F(1, 62) = 135.34$, $p < .001$, $\eta_p^2 = .69$; outliers removed: $F(1, 60) = 206.11$, $p < .001$, $\eta_p^2 = .78$). We then controlled for the effects of nonverbal cognition to determine if the group effect for the comprehension-production difference profile remained after accounting for differences in cognitive level. For the full sample, the covariate for nonverbal cognition ($F(1, 61) = 5.49$, $p = .022$, $\eta_p^2 = .08$) was significantly related to comprehension-production difference scores, but the significant effect of group for comprehension-production difference scores was retained ($F(1, 61) = 52.05$, $p < .001$, $\eta_p^2 = .46$). When the outliers were removed, nonverbal cognition ($F(1, 59) = 1.97$, $p = .166$, $\eta_p^2 = .03$) was not significantly related to the comprehension-production scores, but again, the significant effect of group for the comprehension-production difference scores was retained ($F(1, 59) = 91.84$, $p < .001$, $\eta_p^2 = .61$). We then examined the effects of nonverbal cognition to determine if there was an interaction between group and

nonverbal cognition for comprehension-production difference scores. For the full sample and the sample with the outliers removed, the main effect of group remained significant (full sample: $F(1, 47) = 38.71, p < .001, \eta_p^2 = .45$; outliers removed: $F(1, 45) = 63.38, p < .001, \eta_p^2 = .59$), the main effect of nonverbal cognition was not significant (full sample: $F(1, 47) = 1.21, p = .305, \eta_p^2 = .22$; outliers removed: $F(1, 45) = 0.67, p = .758, \eta_p^2 = .14$), and the interaction between group and nonverbal cognition was not significant (full sample: $F(4, 47) = 0.96, p = .441, \eta_p^2 = .08$; outliers removed: $F(4, 45) = 1.21, p = .318, \eta_p^2 = .10$).

Using meaningful comprehension-production difference scores, no children in the LT group (0%), and 29 children in the ASD group (91%) had negative difference scores that were beyond the standard error of measurement at the 95% confidence interval for the child's chronological age. Based on a Fisher's exact test, the proportion of children with a discrepant comprehension-production profile in the LT and ASD subgroups significantly differed from each other ($p < .001$). Next, we determined the sensitivity and specificity of the meaningful comprehension-production profile as a toddler marker of ASD at approximately 30 months. For the meaningful comprehension-production difference scores, sensitivity was 91% and specificity was 100% with an odds ratio of 547.86 (95% confidence interval of 27.14-11057.69), $p < .001$.

To determine if there was a developmental change in comprehension-production profiles, we first characterized the percentage of children with a discrepant profile across three time points in the larger ASD sample. Fifty children (62%) had a meaningful comprehension-production discrepancy profile at 30 months and 37 (46%) displayed this type of discrepant profile at 44 months; however, only 8 children (10%) had a meaningful discrepancy profile at 66 months.

We conducted a repeated-measures ANOVA (and Friedman's ANOVA) to evaluate the language difference scores over time (30, 44 and 66 months) for the ASD group. There was a significant main effect for time, $F(2, 160) = 28.04, p < .001, \eta_p^2 = .26$ and $\chi_F^2(2) = 50.44, p < .001$. Paired samples t-tests and Wilcoxon signed-rank tests indicated significant differences between the language difference scores at 30 and 44 months ($t(80) = -3.51, p = .001, d = -0.49$ and $T = 2266.00, p < .001, r = 0.40$), 30 and 66 months ($t(80) = -6.77, p < .001, d = -1.18$ and $T = 2872.00, p < .001, r = 0.63$), and 44 and 66 months ($t(80) = -4.38, p < .001, d = -0.66$ and $T = 2267.00, p < .001, r = 0.46$) with comprehension-production difference scores becoming increasingly positive over time. See Table 3 for mean comprehension-production difference scores at each time point.

In order to confirm that this developmental effect was not simply the result of using difference scores (Singer and Willett 2003), we compared the effects of the separate comprehension and production scores at each time point. Using a repeated-measures ANOVA with Time (30, 44, and 66 months) and Language Domain (comprehension, production) as within-subjects effects, we found a significant main effect for Time ($F(2, 160) = 26.67, p < .001, \eta_p^2 = .25$). Contrasts with Bonferroni adjustment revealed that language scores were not significantly higher at Time 2 than Time 1 ($p = .214$), but Time 3 language scores were significantly higher than at Time 1 ($p < .001$). There was also a significant main

effect for Language Domain ($F(1, 80) = 47.80, p < .001, \eta_p^2 = .37$), indicating that comprehension was lower than production. Additionally, there was a significant interaction between Time and Language Domain ($F(2, 160) = 28.04, p < .001, \eta_p^2 = .26$). Using paired samples t-tests to determine the effects of this interaction, we confirmed that comprehension was significantly lower than production at Time 1 ($t(80) = -8.93, p < .001, d = -1.04$) and Time 2 ($t(80) = -4.42, p < .001, d = -0.28$), but did not significantly differ at Time 3 ($t(80) = 1.43, p = .156, d = 0.07$). This interaction effect is illustrated in Figure 1. Similarly the Wilcoxon Signed-Rank tests indicated that the comprehension scores were significantly lower than production scores at Time 1 ($T = 2831.50, p < .001, r = 0.75$) and Time 2 ($T = 2260.50, p < .001, r = .49$), but did not significantly differ at Time 3 ($T = 865.00, p = .124, r = -0.17$).

Discussion

This investigation furthered our understanding of the previously reported discrepant comprehension-production profiles in young children with ASD by examining whether the discrepant profile distinguished toddlers with ASD from late talkers (LTs) who are at risk for SLI. Further, this study tracked the developmental progression of the comprehension-production profile longitudinally using a comprehensive, language-specific measure.

ASD and LT groups similar in age, SES, and expressive language differed significantly in comprehension-production discrepancy scores, even after accounting for nonverbal cognition. Further, there was no interaction between group and nonverbal cognition when considering analysis of comprehension-production difference scores. In characterizing these profiles, we observed distinct differences between these two groups' profiles; the difference scores for children with ASD were negative (i.e., relatively lower comprehension than production compared to age expectations), but the difference scores for the LT group were positive (i.e., comprehension in line with age expectations but production below age expectations). We also found that an overwhelming majority of young children with ASD (24-36 months of age) had a meaningful discrepant comprehension-production profile involving a relative comprehension weakness whereas none of the toddlers in the LT group displayed this profile. These differences suggest discrete language profiles for LT and ASD toddlers.

How should we interpret the clear distinction between the comprehension-production profiles of LTs relative to toddlers with ASD? Because LTs are at risk for SLI (Taylor et al. 2013), one possibility is that although there is evidence for certain areas of overlap in aspects of grammatical and semantic abilities in ASD and SLI (Haebig et al. 2015; Kjelgaard and Tager-Flusberg 2001), an early comprehension-production discrepancy profile is not a common feature of these groups. However, only direct investigation of older children with an actual SLI diagnosis could confirm this possibility. As a group, most LT toddlers move into normal range by 7 years of age and will not have a clinical language deficit (Taylor et al. 2013), but will continue to exhibit low normal range language abilities into and throughout adolescence (Rescorla 2005, 2009). Therefore, we might expect that their early comprehension-production profile would more closely resemble that of TD toddlers. In fact,

a substantial minority of toddlers identified as LTs at 24 months in the present study were late bloomers who were beginning to catch up in language development by 30 months. It would be helpful for future studies to explore comprehension-production discrepancy profiles in larger samples of persistent late talkers vs. late bloomers compared to toddlers with ASD.

Our longitudinal examination of the comprehension-production profile revealed a progressive decrease in comprehension-production differences from 30 to 66 months, which suggests that while a discrepant comprehension-production profile is a relevant marker of ASD at 30 months, it is less likely to be characteristic of ASD during the later preschool years. Our findings conflict with the absence of age effects reported by Kwok et al. (2015) based on their meta-analysis of prior research; however, as noted previously, the very large age ranges employed in that study likely obscured developmental changes. On the other hand, our longitudinal findings confirm previous cross-sectional results (Seol et al. 2014), indicating that the relative comprehension weakness diminishes from toddlerhood through the preschool period. Other cross-sectional studies examining older children, however, have reported discrepant comprehension-production profiles after age six (Barneveld et al. 2014; Kover et al. 2013). Future longitudinal studies need to tease apart whether the discrepant comprehension-production profile later in development re-emerges or whether those who persist in exhibiting a discrepant comprehension-production profile at 66 months continue to display this profile throughout development.

Taken together, our findings from the comparison of LT and ASD toddlers and the longitudinal data for the ASD group at 30 and 44 months is consistent with previous research reporting significant comprehension-production discrepancy profiles in children with ASD (Barbaro and Dissanayake 2012; Barneveld et al. 2014; Ellis Weismer et al. 2010; Hudry et al. 2010; Kover et al. 2013; Luyster et al. 2008; Maljaars et al. 2012; Seol et al. 2014; Volden et al. 2011). However, we found a higher percentage of children with ASD who exhibited a discrepant comprehension-production profile in our smaller ASD-LT comparison sample (91%) than our broader longitudinal sample of children with ASD at a mean age of 30 months (62%). In order to form equivalent groups in terms of expressive language skills, a number of the ASD toddlers with the lowest productive language scores were excluded because the range of language delay displayed by the LT toddlers was less severe (in addition to excluding those ASD toddlers from the broader sample at the upper end of the range without structural language problems). The ASD toddlers with the most severe language deficits tended to be those who had lower comprehension and production abilities; therefore, a limitation of this study is that the smaller, matched sample consisted of fewer toddlers with this type of severe language deficit profile.

Our percentage of children with ASD exhibiting a discrepant comprehension-production profile is also higher than reported in prior literature, which may be explained in terms of differences in sample characteristics. The children in the current study were relatively younger and higher functioning than the sample investigated by Maljaars and colleagues (2012) who reported 31% of their sample had discrepant comprehension-production profiles. While Seol et al. (2014) reported that 43% of their sample displayed discrepant comprehension-production profiles across all age ranges, they found higher percentages

when discrete age ranges were considered (based on cross-sectional data): 56% (20-29 months), 54% (30-39 months), and 23% (40-49 months). Our findings align reasonably well with these percentages in that we observed 39% of the ASD children exhibited a discrepant profile when averaging across the three time points (30, 44, 66 months), with 62% of the broader sample showing this profile at 30 months. In addition, comprehension-production profiles may vary based on the language measures used; all three studies under consideration assessed language abilities using different measures.

Our data, albeit from a relatively limited sample, suggest excellent sensitivity and specificity along with large and significant odds ratios when using a discrepant comprehension-production profile to distinguish toddlers with ASD from LTs. While additional research needs to confirm this early language profile as an age-specific risk marker in ASD, the sensitivity/specificity data from the current study provide suggestive evidence that late talkers and toddlers with ASD tend to diverge with respect to this particular language pattern. Early childhood practitioners (e.g., pediatricians, speech-language pathologists, and developmental psychologists) could potentially use knowledge about a child's relative comprehension and production abilities to assist in making appropriate referrals or to aid diagnostic assessments. This may be particularly relevant when determining whether a child is a late talker who has no additional developmental concerns beyond delayed language production or a child who may have ASD. At the least, these results underscore the notion that best clinical practice is to consider both receptive and expressive language abilities during assessment rather than just considering overall language level. It is worth highlighting the fact that the sensitivity and specificity reported in this investigation are specific to children within the age range studied. A narrow age-range allowed us to pinpoint the utility of this diagnostic indicator at an age when many families are seeking information about whether a child's development is delayed.

There are several additional limitations of the current study not previously mentioned. First, we used the same test, but different versions (the PLS-3 for the LT children and the PLS-4 for the children with ASD), to assess receptive and expressive language abilities. While psychometrics improved from the PLS-3 to the PLS-4 (Zimmerman et al. 2002), previous studies have identified discrepant comprehension-production profiles in children with ASD using the PLS-3 (Hudry et al. 2010) and the PLS-4 (Volden et al. 2011), which suggests that the comprehension-production discrepancy profile is consistently identified using the PLS regardless of version. The Kwok et al. (2015) meta-analysis found no significant effect of language measure on findings related to comprehension-production gaps, but they employed broad categories of clinician administered tests, parent report measures, or mixed methods. It may be useful, nonetheless, for future studies to consider the extent to which specific language measures (not just these general categories of measures) affect the characterization of comprehension-production profiles in children with ASD.

Other limitations of the present study pertain to group matching issues and representativeness of the ASD sample. Although there were non-significant differences with small effect sizes for each of the three matching variables (age, SES, expressive language), the least tight match was for expressive language so it possible that this may have had an effect on the LT-ASD comparisons. When matched on these selected variables the toddlers

with ASD had significantly lower nonverbal cognition than the LT group; therefore, it was necessary to account for this difference statistically. The choice of matching criteria is driven by the particular research question and is an issue of considerable importance and admittedly presents many challenges (Charman 2004; Plante et al. 1993). The broader longitudinal sample in this study included all children with ASD who enrolled in the project who had complete language data at each time point; this group represented a wide range of cognitive and language abilities and autism severity. Like most research studies, this was a convenience/clinical sample rather than an epidemiological sample. We did, however, recruit from the entire state of Wisconsin instead of just the community surrounding the university and provided reimbursement for travel and hotel for families to encourage participation. Nevertheless, children from families who volunteer to participate in research and can sustain participation over several years may not be representative of the general population of children with ASD.

As one last consideration, it is not clear from the present study what role treatment played in the gains in comprehension during this developmental period. However, most treatments for ASD do not directly target comprehension, a point that has previously been criticized (Camarata 2014). A number of the children with ASD in our sample were not receiving separate speech-language therapy in addition to ASD specific intervention over the course of the longitudinal study (10% at 30 months, 23% at 44 months, and 32% at 66 months were enrolled in speech-language intervention according to parent reports collected every six months). Further, as Camarata (2014) notes, there appears to be insufficient emphasis on comprehension stemming from an assumption that targeting expressive language during therapy will result in improvements in receptive language, though there is little evidence to support this. Therefore, we speculate that improvements in comprehension documented here could reflect more broad-based developmental changes, which may or may not be related to treatment. This raises important questions for future studies with respect to whether there are other social or cognitive skills that mediate these developmental changes in comprehension. Based on prior research and results from the current study indicating a relative comprehension weakness for young children with ASD, it is recommended that intervention goals focused directly on improving receptive language/communication abilities be incorporated and evaluated in treatment programs. In other words, parents and clinicians should concentrate on what toddlers with ASD *understand* as well as focusing on their language production.

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References

- American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR). Fourth. Vol. 1. Arlington, VA: American Psychiatric Association; 2000.
- Barbaro J, Dissanayake C. Developmental profiles of infants and toddlers with autism spectrum disorders identified prospectively in a community-based setting. *Journal of Autism and Developmental Disorders*. 2012; 42(9):1939–1948. DOI: 10.1007/s10803-012-1441-z [PubMed: 22310906]
- Barneveld P, Swaab H, van Engeland H, de Sonnevile L. Cross-sectional evidence for a decrease in cognitive function with age in children with autism spectrum disorders? *Autism Research*. 2014; 7(5):527–534. DOI: 10.1002/aur.1380 [PubMed: 25132666]
- Bayley, N. Bayley Scales of Infant Development. Second. New York: Cambridge University Press; 1993.
- Bayley, N. Bayley Scales of Infant and Toddler Development. Third. San Antonio: PsychCorp; 2006.
- Bishop S, Guthrie W, Coffing M, Lord C. Convergent validity of the Mullen Scales of Early Learning and the differential ability scales in children with autism spectrum disorders. *American Journal on Intellectual and Developmental Disabilities*. 2011; 116(5):331–343. DOI: 10.1352/1944-7558-116.5.331 [PubMed: 21905802]
- Boucher J. Research review: Structural language in autistic spectrum disorder - characteristics and causes. *Journal of Child Psychology and Psychiatry*. 2012; 53(3):219–233. DOI: 10.1111/j.1469-7610.2011.02508.x [PubMed: 22188468]
- Camarata S. Early identification and early intervention in autism spectrum disorders: Accurate and effective? *International Journal of Speech-Language Pathology*. 2014; 16(1):1–10. DOI: 10.3109/17549507.2013.858773 [PubMed: 24410017]
- Charman T. Matching preschool children with autism spectrum disorders and comparison children for language Ability: Methodological challenges. *Journal of Autism and Developmental Disorders*. 2004; 34(1):59–64. DOI: 10.1023/B:JADD.0000018075.77941.60 [PubMed: 15098958]
- Charman T, Drew A, Baird C, Baird G. Measuring early language development in preschool children with autism spectrum disorder using the MacArthur Communicative Development Inventory (Infant Form). *Journal of Child Language*. 2003; 30(1):213–236. DOI: 10.1017/S0305000902005482 [PubMed: 12718299]
- Davidson M, Ellis Weismer S. Characterization and prediction of early reading abilities in children on the autism spectrum. *Journal of Autism and Developmental Disorders*. 2014; 44(4):828–845. DOI: 10.1007/s10803-013-1936-2 [PubMed: 24022730]
- Ellis Weismer S. Typical talkers, late talkers, and children with specific language impairment: A language endowment spectrum. *Language Disorders from a Developmental Perspective: Essays in Honor of Robin S Chapman*. 2007:83–101.
- Ellis Weismer S, Gernsbacher M, Stronach S, Karasinski C, Eernisse E, Venker C, Sindberg H. Lexical and grammatical skills in toddlers on the autism spectrum compared to late talking toddlers. *Journal of Autism and Developmental Disorders*. 2011; 41(8):1065–1075. DOI: 10.1007/s10803-010-1134-4 [PubMed: 21061053]
- Ellis Weismer S, Kover S. Preschool language variation, growth, and predictors in children on the autism spectrum. *Journal of Child Psychology and Psychiatry*. 2015; 56(12):1327–1337. DOI: 10.1111/jcpp.12406 [PubMed: 25753577]
- Ellis Weismer S, Lord C, Esler A. Early language patterns of toddlers on the autism spectrum compared to toddlers with developmental delay. *Journal of Autism and Developmental Disorders*. 2010; 40(10):1259–1273. DOI: 10.1007/s10803-010-0983-1 [PubMed: 20195735]
- Ellis Weismer S, Venker C, Evans J, Moyle M. Fast mapping in late-talking toddlers. *Applied Psycholinguistics*. 2011; 34:69–89. DOI: 10.1017/S0142716411000610
- Fenson, L., Marchman, V., Thal, D., Dale, P., Reznick, J., Bates, E. MacArthur-Bates Communicative Development Inventories: User's Guide and Technical Manual. Second. Baltimore: Paul H. Brookes Publishing Co; 2007.

- Fernald A, Marchman V. Individual differences in lexical processing at 18 months predict vocabulary growth in typically developing and late-talking toddlers. *Child Development*. 2012; 83(1):203–222. DOI: 10.1111/j.1467-8624.2011.01692.x [PubMed: 22172209]
- Field, A. *Discovering Statistics Using IBM SPSS Statistics*. 4th. London: SAGE Publications Ltd; 2013.
- Girolametto L, Pearce P, Weitzman E. Effects of lexical intervention on the phonology of late talkers. *Journal of Speech, Language, and Hearing Research*. 1997; 40:338–348.
- Gotham K, Pickles A, Lord C. Standardizing ADOS scores for a measure of severity in autism spectrum disorders. *Journal of Autism and Developmental Disorders*. 2009; 39(5):693–705. DOI: 10.1007/s10803-008-0674-3 [PubMed: 19082876]
- Guinchat V, Chamak B, Bonniau B, Bodeau N, Perisse D, Cohen D, Danion A. Very early signs of autism reported by parents include many concerns not specific to autism criteria. *Research in Autism Spectrum Disorders*. 2012; 6(2):589–601. DOI: 10.1016/j.rasd.2011.10.005
- Haebig E, Kaushanskaya M, Ellis Weismer S. Lexical processing in school-age children with autism spectrum disorder and children with specific language impairment: The role of semantics. *Journal of Autism and Developmental Disorders*. 2015; 45(12):4109–4123. DOI: 10.1007/s10803-015-2534-2 [PubMed: 26210517]
- Hawa V, Spanoudis G. Toddlers with delayed expressive language: An overview of the characteristics, risk factors and language outcomes. *Research in Developmental Disabilities*. 2014; 35(2):400–407. DOI: 10.1016/j.ridd.2013.10.027 [PubMed: 24334229]
- Hudry K, Leadbitter K, Temple K, Slonims V, McConachie H, Aldred C, et al. Preschoolers with autism show greater impairment in receptive compared with expressive language abilities. *International Journal of Language & Communication Disorders*. 2010; 45(6):681–690. DOI: 10.3109/13682820903461493 [PubMed: 20102259]
- Jarrold C, Boucher J, Russel J. Language profiles in children with autism. *Autism*. 1997; 1(1):57–76.
- Jones S, Smith L. Object name learning and object perception: A deficit in late talkers. *Journal of Child Language*. 2005; 32(1):223–240. DOI: 10.1017/S0305000904006646 [PubMed: 15779885]
- Kjelgaard M, Tager-Flusberg H. An investigation of language impairment in autism: Implications for genetic subgroups. *Language and Cognitive Processes*. 2001; 16(2–3):287–308. DOI: 10.1080/01690960042000058 [PubMed: 16703115]
- Kover S, McDuffie A, Hagerman R, Abbeduto L. Receptive vocabulary in boys with autism spectrum disorder: Cross-sectional developmental trajectories. *Journal of Autism and Developmental Disorders*. 2013; 43(11):2696–2709. DOI: 10.1007/s10803-013-1823-x [PubMed: 23588510]
- Kwok E, Brown H, Smyth R, Oram J. Meta-analysis of receptive and expressive language skills in autism spectrum disorder. *Research in Autism Spectrum Disorders*. 2015; 9:202–222. DOI: 10.1016/j.rasd.2014.10.008
- Lord, C., Rutter, M., DiLavore, P., Risi, S. *Autism Diagnostic Observation Schedule*. Los Angeles: Western Psychological Services; 2002.
- Loucas T, Charman T, Pickles A, Simonoff E, Chandler S, Meldrum D, Baird G. Autistic symptomatology and language ability in autism spectrum disorder and specific language impairment. *Journal of Child Psychology and Psychiatry*. 2008; 49(11):1184–1192. DOI: 10.1111/j.1469-7610.2008.01951.x [PubMed: 19017030]
- Loukusa S, Makinen L, Kuusikko-Gauffin S, Ebeling H, Moilanen I. Theory of mind and emotion recognition skills in children with specific language impairment, autism spectrum disorder and typical development: Group differences and connection to knowledge of grammatical morphology, word-finding abilities and verbal working memory. *International Journal of Language & Communication Disorders*. 2014; 49(4):498–507. DOI: 10.1111/1460-6984.12091 [PubMed: 24888967]
- Luyster R, Gotham K, Guthrie W, Coffing M, Petrak R, Pierce K, et al. The Autism Diagnostic Observation Schedule-Toddler Module: A new module of a standardized diagnostic measure for autism spectrum disorders. *Journal of Autism and Developmental Disorders*. 2009; 39(9):1305–1320. DOI: 10.1007/s10803-009-0746-z [PubMed: 19415479]

- Luyster R, Kadlec M, Carter A, Tager-Flusberg H. Language assessment and development in toddlers with autism spectrum disorders. *Journal of Autism and Developmental Disorders*. 2008; 38(8): 1426–1438. DOI: 10.1007/s10803-007-0510-1 [PubMed: 18188685]
- Luyster R, Lopez K, Lord C. Characterizing communicative development in children referred for autism spectrum disorders using the MacArthur-Bates Communicative Development Inventory (CDI). *Journal of Child Language*. 2007; 34(3):623–654. DOI: 10.1017/S0305000907008094 [PubMed: 17822142]
- Maljaars J, Noens I, Scholte E, van Berckelaer-Onnes I. Language in low-functioning children with autistic disorder: Differences between receptive and expressive skills and concurrent predictors of language. *Journal of Autism and Developmental Disorders*. 2012; 42(10):2181–2191. DOI: 10.1007/s10803-012-1476-1 [PubMed: 22350453]
- McGregor K, Berns A, Owen A, Michels S, Duff D, Bahnsen A, Lloyd M. Associations between syntax and the lexicon among children with or without ASD and language impairment. *Journal of Autism and Developmental Disorders*. 2012; 42(1):35–47. DOI: 10.1007/s10803-011-1210-4 [PubMed: 21365354]
- Moyle M, Ellis Weismer S, Evans J, Lindstrom M. Longitudinal relationships between lexical and grammatical development in typical and late-talking children. *Journal of Speech, Language, and Hearing Research*. 2007; 50:508–528. DOI: 10.1044/1092-4388(2007/035)
- Mullen, E. Mullen Scales of Early Learning. Minneapolis: Pearson, Inc.; 1995.
- Norbury C. Barking up the wrong tree? Lexical ambiguity resolution in children with language impairments and autistic spectrum disorders. *Journal of Experimental Child Psychology*. 2005; 90(2):142–171. DOI: 10.1016/j.jecp.2004.11.003 [PubMed: 15683860]
- Paul, R., Ellis Weismer, S. Late talking in context: The clinical implications of delayed language development. In: Rescorla, L., Dale, P., editors. *Late Talkers: Language Development, Interventions, and Outcomes*. Baltimore: Paul H. Brookes Publishing Co; 2013. p. 203–217.
- Petrucelli N, Bavin E, Bretherton L. Children with specific language impairment and resolved late talkers: Working memory profiles at 5 years. *Journal of Speech Language and Hearing Research*. 2012; 55:1690–1704. DOI: 10.1044/1092-4388(2012/11-0288)b
- Pickles A, Anderson D, Lord C. Heterogeneity and plasticity in the development of language: A 17-year follow-up of children referred early for possible autism. *Journal of Child Psychology and Psychiatry and Allied Disciplines*. 2014; 55(12):1354–1362. DOI: 10.1111/jcpp.12269
- Plante E, Swisher L, Kiernan B, Restrepo M. Language matches: Illuminating or confounding? *Journal of Speech & Hearing Research*. 1993; 36(4):772–776. [PubMed: 8377489]
- Reiner Hess C, Landa R. Predictive and concurrent validity of parent concern about young children at risk for autism. *Journal of Autism and Developmental Disorders*. 2012; 42(4):575–584. DOI: 10.1007/s10803-011-1282-1 [PubMed: 21584850]
- Rescorla L. Age 13 language and reading outcomes in late-talking toddlers. *Journal of Speech, Language, and Hearing Research*. 2005; 48:459–472.
- Rescorla L. Age 17 language and reading outcomes in late-talking toddlers: Support for a dimensional perspective on language delay. *Journal of Speech, Language, and Hearing Research*. 2009; 52:16–30.
- Rescorla, L., Dale, P. *Late Talkers: Language Development, Interventions, and Outcomes*. Rescorla, L., Dale, P., editors. Baltimore: Paul H Brookes Pub Co; 2013.
- Robertson S, Ellis Weismer S. Effects of treatment on linguistic and social skills in toddlers with delayed language development. *Journal of Speech, Language, and Hearing Research*. 1999; 42(5): 1234–1248. doi:1092-4388/99/4205-1234.
- Rogers S, Hepburn S, Stackhouse T, Wehner E. Imitation performance in toddlers with autism and those with other developmental disorders. *Journal of Child Psychology and Psychiatry*. 2003; 44(5):763–781. [PubMed: 12831120]
- Rutter, M., Bailey, A., Lord, C. *The Social Communication Questionnaire*. Los Angeles: Western Psychological Services; 2003.
- Rutter M, Le Couteur A, Lord C. *Autism Diagnostic Interview-Revised (Toddler Research Version)*. 2003

- Seol K, Song S, Kim K, Oh S, Kim Y, Im W, et al. A comparison of receptive-expressive language profiles between toddlers with autism spectrum disorder and developmental language delay. *Yonsei Medical Journal*. 2014; 55(6):1721–1728. DOI: 10.3349/ymj.2014.55.6.1721 [PubMed: 25323912]
- Singer, J., Willett, J. *Applied Longitudinal Data Analysis*. New York: Oxford University Press; 2003.
- Tager-Flusberg H, Cooper J. Present and future possibilities for defining a phenotype for specific language impairment. *Journal of Speech, Language, and Hearing Research*. 1999; 42:1275–1278.
- Thal D, Bates E, Goodman J, Jahn-Samilo J. Continuity of language abilities: An exploratory study of late- and early-talking toddlers. *Developmental Neuropsychology*. 1997; 13(3):239–273. DOI: 10.1080/87565649709540681
- Venker C, Ray-Subramanian C, Bolt D, Ellis Weismer S. Trajectories of autism severity in early childhood. *Journal of Autism and Developmental Disorders*. 2014; 44(3):546–563. DOI: 10.1007/s10803-013-1903-y [PubMed: 23907710]
- Volden J, Smith I, Szatmari P, Bryson S, Fombonne E, Mirenda P, et al. Using the Preschool Language Scale, Fourth Edition to characterize language in preschoolers with autism spectrum disorders. *American Journal of Speech-Language Pathology*. 2011; 20(3):200–208. DOI: 10.1044/1058-0360(2011/10-0035) [PubMed: 21478278]
- Whitehouse A, Barry J, Bishop D. The broader language phenotype of autism: a comparison with specific language impairment. *Journal of Child Psychology and Psychiatry*. 2007; 48(8):822–30. DOI: 10.1111/j.1469-7610.2007.01765.x [PubMed: 17683454]
- Woynaroski T, Yoder P, Watson L. Atypical cross-modal profiles and longitudinal associations between vocabulary scores in initially minimally verbal children with ASD. *Autism Research*. 2016; 9(2): 301–310. DOI: 10.1002/aur.1516 [PubMed: 26180010]
- Zimmerman, I., Steiner, V., Pond, R. *Preschool Language Scale*. Third. San Antonio: The Psychological Corporation; 1992.
- Zimmerman, I., Steiner, V., Pond, R. *Preschool Language Scale*. Fourth. San Antonio: PsychCorp; 2002.

Figure 1.

Language comprehension and production over time for children with ASD. The black line indicates comprehension and the gray line indicates production. Error bars indicate 95% confidence intervals. Asterisks indicate significant differences between comprehension and production. $N = 81$ at each age (30, 44, and 66 months).

Table 1

Summary of studies examining comprehension-production profiles in children with ASD.

Study	Terminology used to describe the profile					Method of determining difference				Was a meaningful difference considered?
	Atypical	Expressive Language Advantage	Discrepancy/ Difference/ Gap	Relative Impairment in Comprehension	Other	Visual Examination of Graph	Statistical Domain Comparison	Difference/ Discrepancy Scores	Categorized	
Barbaro and Dissanyake (2012)	X						X			
Bameveld et al. (2014)				X			X			
Charman et al. (2003)	X			X		X				
Ellis Weismer et al. (2010)	X			X			X			
Hudry et al. (2010)	X	X				X	X			
Jarrold et al. (1997)		X					X	X		
Kjelgaard & Tager-Flusberg (2001)			X				X	X		X ^b
Kover et al. (2013)	X	X	X				X	X	X	X ^c
Kwok et al. (2015)	X	X	X							
Loucas et al. (2008)			X					X		
Luyster et al. (2007)		X	X			X				
Luyster et al. (2008)		X	X	X			X			
Maljaars et al. (2012)			X				X		X	
Pickles et al. (2014)			X					X		
Seol et al. (2014)					X ^a					
Volden et al. (2011)	X	X	X					X		

^aLanguage dominant type (expressive, receptive, or non-dominant);

^bA meaningful difference was determined if the difference scores comparing Peabody Picture Vocabulary Test (PPVT) and Expressive Vocabulary Test (EVT) standard scores (not the Clinical Evaluation of Language Fundamentals comparisons) was more than one standard deviation;

^cA difference score was determined to be meaningful if it was beyond the standard error of measurement at the 95% confidence interval.

Table 2

LT and ASD group characteristics at 30 months.

	LT (<i>n</i> = 32)				ASD (<i>n</i> = 32)					
	<i>M</i>	<i>SD</i>	Range	<i>z</i> _{skewness}	<i>z</i> _{kurtosis}	<i>M</i>	<i>SD</i>	Range	<i>z</i> _{skewness}	<i>z</i> _{kurtosis}
Age ^a	29.94	0.25	29–30	−9.17	16.35	30.59	3.70	24–36	0.02	−1.51
SES ^b	15.06	1.98	12–18	−1.12	−1.24	14.81	2.46	12–19	0.86	−1.49
Nonverbal Cognition ^c	7.56	2.02	4–11	−0.08	−1.18	3.50	2.40	0–9	1.72	−0.30
Autism Severity ^d	—	—	—	—	—	7.47	1.69	3–10	—	—
Language Comprehension ^e	113.94	19.42	75–145	−0.49	−0.79	64.97	13.92	50–117	5.06	6.79
Log ₁₀ -transformed Language Comprehension (outliers removed) ^f	2.05	0.08	1.88–2.16	−1.36	−0.23	1.79	0.06	1.70–1.92	1.63	−0.12
Language Production ^g	90.75	9.88	71–109	−0.38	−0.72	86.69	8.95	71–110	1.96	0.86
Comprehension-Production Difference ^h	23.19	17.01	−2–74	2.24	1.54	−21.72	13.70	−48–32	4.12	8.73
Comprehension-Production Difference (outliers removed) ⁱ	21.55	14.49	−2–54	0.90	−0.48	−23.45	9.72	−48–7	−1.19	0.70

Note.

^aIn months;^bIndicated by mother's reported years of education;^cRaw scores based on a total of 11 nonverbal items from the Bayley-II (LT) or Bayley-III (ASD);^dCalculated from the Autism Diagnostic Observation Schedule (ADOS) based on Gotham et al. (2009);^eReceptive language performance based on the PLS-3 (LT) or PLS-4 (ASD) Auditory Comprehension (AC) standard score;^fTwo ASD outliers removed (*n* = 30);^gExpressive language performance based on the PLS-3 (LT) or PLS-4 (ASD) Expressive Communication (EC) standard score;^hThe difference score between the PLS AC and EC subtest standard scores (Difference = AC − EC, where negative scores indicate an atypical comprehension-production language profile with higher receptive than expressive language abilities);ⁱLT (*n* = 31) and ASD (*n* = 31).

Table 3

ASD group characteristics for the longitudinal sample.

	30 months (<i>n</i> = 81)			44 months (<i>n</i> = 81)			66 months (<i>n</i> = 81)		
	<i>M</i>	<i>SD</i>	Range	<i>M</i>	<i>SD</i>	Range	<i>M</i>	<i>SD</i>	Range
Age ^a	30.38	3.89	24–36	43.62	3.99	37–51	65.85	4.54	57–76
SES ^b	14.21	2.01	11–20						
Nonverbal Cognition	77.32 ^{c,j}	15.17	37–119	74.73 ^{d,j}	22.41	34–140	75.65 ^d	19.25	33–108
Autism Severity ^e	7.44	1.80	4–10	7.26	1.77	3–10	7.21	1.79	3–10
Language Comprehension ^f	59.51	12.23	50–117	65.23	23.35	50–145	79.19	25.70	50–129
Language Production ^g	71.41	10.44	50–103	71.21	18.61	50–125	77.40	25.47	50–133
Total Language ^h	62.05	10.51	50–101	65.75	21.65	50–138	77.23	26.41	50–131
Comprehension-Production Difference ⁱ	-11.90	12.00	-48–38	-5.98	12.17	-38–29	1.79	11.24	-32–45

Note. SES = socioeconomic status;

^aIn months;

^bIndicated by mother's reported years of education;

^cNonverbal ratio IQ scores from the Bayley-III;

^dNonverbal ratio IQ scores from the Mullen;

^eCalculated from the *Autism Diagnostic Observation Schedule* (ADOS) and ADOS-Toddler based on Gotham et al. (2009);

^f*Preschool Language Scale* (PLS-4) Auditory Comprehension (AC) subscale standard scores;

^gPLS-4 Expressive Communication (EC) subscale standard scores;

^hPLS-4 Total Language standard scores (receptive and expressive combined scores);

ⁱThe difference between the PLS-4 AC and EC subtest standard scores (Difference = AC – EC, where negative scores indicate an atypical language profile with higher receptive than expressive language abilities);

^jBased on data available for 80 participants.