Published in final edited form as:

J Autism Dev Disord. 2016 July ; 46(7): 2501–2507. doi:10.1007/s10803-016-2756-y.

Ages of Language Milestones as Predictors of Developmental Trajectories in Young Children with Autism Spectrum Disorder

Sara T. Kover[1], **Sarah R. Edmunds**[2], and **Susan Ellis Weismer**[3]

Sara T. Kover: skover@u.washington.edu; Sarah R. Edmunds: sre26@u.washington.edu; Susan Ellis Weismer: ellisweismer@wisc.edu

[1]Department of Speech and Hearing Sciences, University of Washington

[2]Department of Psychology, University of Washington

[3]Department of Communication Sciences and Disorders, University of Wisconsin-Madison

Abstract

Recognizing early risk markers in young children with autism spectrum disorder (ASD) is critical for timely diagnosis and intervention. The purpose of this study was to extend previous findings regarding language milestones to a longitudinal design, in which ages of expressive language milestones (i.e., first words, first phrases) could serve as predictors of developmental trajectories in a heterogeneous sample of young children with ASD (N=98; age at first assessment: M=32 months, SD=5). Age of first words predicted trajectories of expressive language and adaptive skills; number of words predicted each outcome examined. Because these aspects of early language show promise as potential indicators of later functional outcomes, future research on developmental processes as they relate to individual differences will be particularly informative.

Keywords

first words; trajectories; language development

Recognizing early risk markers and prognostic indicators in young children with autism spectrum disorder (ASD) is critical for timely diagnosis and intervention (Luyster, Seery, Talbott, & Tager-Flusberg, 2011). A large body of evidence suggests that early language acquisition predicts later functional and developmental outcomes (Anderson, Oti, Lord, & Welch, 2009; Bennett et al., 2008; Loucas et al., 2008). In fact, several studies have identified certain benchmarks as indicative of later outcomes, including “useful language” by age 5 (Rutter, 1970; Howlin, Goode, Hutton, & Rutter, 2004). Rutter (1970) reported that language use by 5 years of age differentiated later general adaptive and social outcomes. Howlin et al. (2004) found that children with useful speech by age 5 were more social and required fewer residential support services. Beyond general indices of language in early

Corresponding Author: Sara T. Kover, Ph.D., 1417 N.E. 42nd St., Seattle, WA 98105, skover@u.washington.edu, Phone: (206) 543-7888.

Sara T. Kover, University of Washington; Sarah R. Edmunds, University of Washington; Susan Ellis Weismer, University of Wisconsin-Madison.

Preliminary results were presented at the 2014 International Meeting for Autism Research in Atlanta, GA.

The authors have no conflicts of interest to declare.

school age children, specific language skills during very early childhood (e.g., producing 10 words by 18 months; Hedvall et al., 2015) have also been linked to later functional outcomes and may provide a way to understand individual variability. In particular, language milestones—most notably age of first words (Mayo, Chlebowski, Fein, & Eigsti, 2013) and age of first phrases (Kenworthy et al., 2012)—have been found to predict developmental outcomes in children with ASD.

It is important to understand the utility of language milestones as prognostic indicators because they are readily reported by parents and screened by practitioners. Expressive language, such as onset of first words, is often the first reported parental concern about a later diagnosed child (Coonrod & Stone, 2004; Chawarska et al., 2007; Herlihy, Knoch, Vibert, & Fein, 2013). The American Academy of Pediatrics recommends that physicians use standardized instruments to screen for developmental delays at 9, 18, 24 and 36 months using screeners such as the Ages and Stages Questionnaires (Squires, Bricker, & Potter, 2009) and to screen for ASD at 18 and 24 months (Johnson & Myers, 2007). The screening process for both general delay and ASD includes assessing expressive and receptive language in terms of whether particular benchmarks have been reached by the age of screening (Ibanez, Stone, & Coonrod, 2014; Johnson & Myers, 2007; Pierce et al., 2011). Parents' awareness and physicians' regular assessment of language milestones make them a practical potential indicator of functional outcomes.

Recently, Mayo et al. (2013) addressed whether age of first words predicted 4.5-year-olds' outcomes and whether there was an age for the onset of spoken words that particularly distinguished children with better vs. worse later outcomes. This retrospective study included 119 children with ASD, who were 3 – 7 years old (mean age = 52 months; $SD = 6$). Age of first words ($M = 23$ months; $SD = 10$) was obtained from parent report on the Autism Diagnostic Interview-Revised (ADI-R; Rutter, Le Couteur, & Lord, 2003). Cognitive development was assessed with the Mullen Scales of Early Learning (MSEL; Mullen, 1995) and adaptive functioning was assessed with the Vineland Adaptive Behavior Scales (VABS; Sparrow, Balla, & Cicchetti, 1984). After excluding cases of regression, participants were categorized as having or not having first words by 18, 24, 30, and 36 months of age. The authors compared each set of participants (with and without first words) at each age on expressive and receptive language, cognitive, and adaptive functioning outcomes. They found that age of first words distinguished those with better outcomes beginning at the 24-month benchmark. This study suggested that children who have not spoken their first words by age two may be at risk for a host of later functional deficits; however, categorizing age of first words, which is a continuous variable, may have obscured meaningful variability (Rucker, McShane, & Preacher, 2015).

Like age of first words, the timing of the acquisition of phrase speech may be an important indicator of outcomes. In older high-functioning children with ASD (mean age of 9 years), age of phrase speech before 24 months as opposed to before 36 months distinguished between those with better or worse adaptive communication (Kenworthy et al., 2012). Age of phrase or fluent speech attainment has also been shown to be positively associated with nonverbal IQ and social impairment for children without phrase speech at age 4 (Wodka,

Mathy, & Kalb, 2013). As in the case of the Mayo et al. (2013) study, language milestone data from Kenworthy et al. and Wodka et al. were based on the ADI-R (Rutter et al., 2003).

Several methodological limitations impact the conclusions that can be drawn from previous research. First, examining cognitive and adaptive skills at only one time point precludes investigation of the relationship between ages of milestones and *rate* of development. Indeed, children with ASD may have slower rates of language growth compared to typically developing children (Anderson et al., 2007), potentially affecting their ability to learn from and adapt to their environment over time. Second, excluding children who experienced regression (Mayo et al., 2013) or children with IQs in the intellectual disability range (i.e., < 70; Kenworthy et al., 2012) limits the generalizability of the findings, particularly given the heterogeneity associated with ASD. Third, there are risks to retrospective recall about language development (Russell, Miller, Ford, & Goslding, 2014)—particularly telescoping (i.e., reporting greater delays as children grow older) in parent report for older children (Hus, Taylor, & Lord, 2011). That is, estimates of age of first words may be differentially worse for older children, whose developmental milestones may have occurred years prior to the time of the interview.

The purpose of the current study was to extend work on age of first words and age of first phrases to a longitudinal design, in which language milestones could serve as predictors of developmental trajectories in a heterogeneous sample of children with ASD. Risk of telescoping was reduced in the current sample due to the young and restricted ages of children at the time of the ADI-R (toddler research version; Le Couteur, Rutter, Lord, & DiLavore, 2006; see Lord, Shulman, DiLavore, 2004). We hypothesized that ages of language milestones would predict levels of ability and rates of change for language, nonverbal cognition, and adaptive skills.

Methods

Participants (N = 98; see Table 1) were drawn from a larger longitudinal study on early development in ASD with up to four annual assessments at approximately 2 ½, 3 ½, 4 ½, and 5 ½ years of age (e.g., Ellis Weismer et al., 2011; Venker, Eernisse, Saffran, & Ellis Weismer, 2013; Davidson & Ellis Weismer, 2014). Appropriate institutional review board approval was obtained along with written parental consent. All children were monolingual English speakers. The toddler research ADI-R (Rutter et al., 2003) was administered at the initial visit and there were 116 participants for whom item-level data from their reliably administered ADI-R could be examined. Of these 116 participants, 98 participants had achieved first words. All analyses are based on these 98 participants with first words or the subset thereof for which the targeted language milestone was applicable (e.g., 30 participants had attained first phrases).

Measures

Diagnosis of ASD was based on best estimate clinical diagnosis using DSM-IV TR criteria and information from the ADOS (Lord, Rutter, DiLavore, & Risi, 2002) or ADOS-T (Luyster et al., 2009) and the toddler research version of the ADI-R (Rutter et al., 2003). Predictors of developmental trajectories were drawn from the ADI-R, including the primary

predictors (i.e., age of first words, age of first phrases) and a secondary, exploratory predictor (i.e., number of words), described further below. Each predictor was an age in months, with the exception of number of words. As defined on the ADI-R, first words refers to the meaningful use of single words other than *mama* or *dada* and first phrases refers to flexible, meaningful use of two words including a verb (Rutter et al., 2003). According to the ADI-R, for first words, parents are prompted to provide examples and evidence that the child knew their meaning. For first phrases, the parent is specifically asked about phrases with two or three words that were not learned as a single-meaning unit. The current number of words produced by the child at the time of interview ranged from 0 to 100, with 100 taken as the estimate for 99 or more words ($n = 24$). For current words, the focus is on the previous week of time, and parents are probed regarding names and objects the child knows. In each case, the examiner makes a scoring judgment based on what the parent reports.

The four outcome variables were based on three norm-referenced assessments, which were administered at each annual visit in which the child participated. Receptive and expressive language standard scores were drawn from the Auditory Comprehension and Expressive Communication subscales of the Preschool Language Scale (PLS-4; Zimmerman, Steiner, & Pond, 2002). Nonverbal cognition was indexed with MSEL Visual Reception T-scores. Adaptive behavior was the overall adaptive behavior composite on the VABS-II (Sparrow et al., 2005).

Analysis Strategy

Hierarchical linear models were estimated separately for each of the four outcome variables: receptive language, expressive language, nonverbal cognition, and adaptive behavior. Age of first words was included as a predictor in all models to aid interpretation of the role of this language milestone across different subsets of children controlling for other language indicators. We assumed a variable occasion design, coding time in terms of age in months when entered as a Level 1 predictor. Time was centered at the average child age across measurement of the outcome variables, age 45 months, and both the intercepts and slopes were treated as random across children. Although visual inspection of individual slopes indicated some nonlinearity, linear slopes were assumed due to the relatively small number of data points and to preserve parsimony of interpretation. We note that reliability estimates for slope were much lower than for intercepts, as would be expected given our modest number of time points per child. In each of our models specified, Level 2 child variables were entered as predictors of both the random intercept and slope. All estimated models converged in fewer than 2000 iterations.

Results

The results of the primary analyses are presented in Table 2. Age of first words positively predicted rate of change for adaptive behavior, $t(96) = 2.04$, $p = .045$. With each unit increase in age of first words (i.e., one month later), the predicted slope for adaptive behavior increased by .008. As the sole predictor, age of first words predicted neither level of ability nor rate of change for any other outcome. For the 30 participants with phrases, age of first words negatively predicted level of expressive language, controlling for age of first

phrases, $t(27) = -2.19$, $p = .037$. That is, earlier age of first words related to better expressive language at age 45 months, controlling for age of first phrases. Age of first phrases did not significantly predict any outcome.

In addition to these a priori predictors, we examined an alternative parent report metric of expressive language: number of words produced at time of interview. Results from this exploratory analysis are in Table 3. Controlling for age of first words, number of words produced positively predicted level of ability for every outcome: receptive language, $t(94) = 4.09$, $p < .001$, expressive language, $t(94) = 5.35$, $p = < .001$, nonverbal cognition, $t(89) = 2.59$, $p = .011$, and adaptive behavior, $t(94) = 5.46$, $p < .001$. The more words children produced at their first visit, the greater their outcomes at 45 months. In addition, for adaptive behavior, both age of first words, $t(94) = 2.04$, $p = .044$, and number of words, $t(94) = -2.12$, $p = .037$, predicted variability in slopes. The older children were when they produced their first words and the fewer words they knew at about 2 ½ years, the greater the rate of increase in their adaptive behavior over time.

Discussion

The purpose of this study was to extend previous research on ages of language milestones and later developmental outcomes to a longitudinal design in which ages of two language milestones could serve as predictors of trajectories in a heterogeneous sample of young children with ASD. We found that age of first words was related only to some aspects of later development. In contrast to other studies, we did not find a relationship between age of first phrases and later development, when controlling for age of first words.

Age of first words predicted trajectories of expressive language and adaptive skills, but not receptive language or nonverbal cognition. Young children with earlier first words had higher levels of expressive language, controlling for the age of first phrases, and those with later first words made faster gains in adaptive skills. It is not surprising that earlier acquisition of productive vocabulary would afford opportunities for greater overall expressive language ability, as suggested by Mayo et al. (2013). In addition, those who acquired first words later had more ground to make up and thus, would have greater leeway in attaining faster rates of development for adaptive skills. However, this latter result is counter to the general expectation that earlier acquisition or stronger ability relates to faster growth or better outcomes (Anderson et al., 2009; Bennett et al., 2008; Bennett et al., 2014). It is apparent that language development—whether in terms of timing of milestones, absolute ability, or presence of impairment—is likely to relate to the vast individual differences in developmental trajectories observed in ASD (Anderson et al., 2007). The specific effect may be a function of any number of factors, including the subsample of participants, whether presence of clinically meaningful delay is considered, the developmental period examined, and the outcome measures selected.

The current study fails to support age of first words as a universal predictor of later development. Mayo et al. (2013) found age of first words to be predictive of each of the outcomes examined; however, their sample included many children who achieved first words after 24 months, whereas the average age of first words was less than 20 months in the

current sample. That is, restriction in range of ages of milestones and/or differences between samples could in part account for the discrepant findings. Especially given the contrasting results between the current study and previous research, caution is warranted given the statistical limitations of the current models due to modest sample sizes. Relatedly, we found no effects for age of first phrases, despite converging evidence of this language milestone as a predictor of other aspects of language and adaptive skills (Kenworthy et al., 2012; Wodka et al., 2013). While lack of power could account for the null effects for age of first phrases, it is also possible that age of first words is the language milestone that better signals a positive trajectory, with first words springboarding development across domains regardless of the timing of phrase speech. Future research is needed to test this hypothesis.

In addition to ages of milestones, we considered an alternative predictor: number of words produced. Although not a language milestone, number of words provided a point of comparison between *timing* of expressive language acquisition and the *amount* of expressive vocabulary a child has acquired, both drawn from the same parent-report measure. We found that number of words was a positive predictor of level of receptive language, expressive language, nonverbal cognitive skills, and adaptive behavior. It is possible that parental difficulty interpreting ADI-R prompts (e.g., for words that are used meaningfully, phrases that are used flexibly) affected the utility of these age-related milestone items as predictors of later development. Better accuracy in estimating number of words rather than ages of milestones—or the increased variability in scores for number of words—could have led to greater ability to detect its effect.

Although our findings suggest that ages of language milestones may be prognostic markers of some outcomes, the exploratory analysis for number of words serves as a reminder that other aspects of early language are critical to consider. First, future research should consider the temporal interaction of age of first words with number of words; rapidly gaining productive vocabulary could have a protective effect, even if first words are later. In addition, parental linguistic responsiveness in the first year of life relates to the timing of language milestones in typical development (Tamis-LeMonda, Bornstein, & Baumwell, 2001) and is a value-added predictor of subsequent expressive language growth in minimally verbal children with ASD (Yoder, Watson & Lambert, 2015). Last, children's attentional patterns when learning words (e.g., attention to child-directed speech [Nadig et al., 2007], to faces vs. objects [Droucker, Curtin, & Voulomanos, 2013], and during interactions with caregivers [e.g., Siller & Sigman, 2008]) also undoubtedly contribute to age and rate of language acquisition. Studying these complex factors will be relevant to understanding trajectories of development in children with ASD (Naigles, 2013).

Conclusions

To some extent, age of first words predicted developmental trajectories of functional behavior. Language milestones are commonly noted by parents and assessed by primary care physicians (e.g., Herlihy et al., 2013; Johnson & Myers, 2007); thus, they may help to flag when immediate intervention is justified (Paul & Ellis Weismer, 2013). Especially in the context of very early intervention for at-risk or symptomatic infants (Bradshaw, Steiner, Gengoux, & Koegel, 2014; Rogers et al., 2014; Webb, Jones, Kelly, & Dawson, 2014),

milestones might provide insight into treatment responsiveness and appropriateness, or give justification for monitoring or treatment (Ellis Weismer, 2000; Paul, 2000). Language milestones—by virtue of hinting at *what* and *when* a child is learning—point to the importance of studying indicators of learning processes (i.e., *how*). Critically, early language learning processes (e.g., fast-mapping of vocabulary) are likely to be optimally informative for predicting developmental trajectories and for understanding differences among individuals with ASD.

Acknowledgments

This research was supported by NIH grants R01 DC007223, T32 DC005359, and P30HD03352. We offer our sincere thanks to all of the families who participated in this research. We would also like to thank Dr. Daniel Bolt for his statistical consultation.

References

Anderson DK, Lord C, Risi S, DiLavore PS, Shulman C, Thurm A, … Pickles A. Patterns of growth in verbal abilities among children with autism spectrum disorder. Journal of Consulting and Clinical Psychology. 2007; 75(4):594–604. DOI: 10.1037/0022-006X.75.4.594 [PubMed: 17663613]

Anderson DK, Oti RS, Lord C, Welch K. Patterns of growth in adaptive social abilities among children with autism spectrum disorders. Journal of Abnormal Child Psychology. 2009; 37(7):1019–1034. DOI: 10.1007/s10802-009-9326-0 [PubMed: 19521762]

Bennett T, Szatmari P, Bryson S, Volden J, Zwaigenbaum L, Vaccarella L, … Boyle M. Differentiating autism and asperger syndrome on the basis of language delay or impairment. Journal of Autism and Developmental Disorders. 2008; 38(4):616–625. DOI: 10.1007/s10803-007-0428-7 [PubMed: 17721697]

Bennett TA, Szatmari P, Georgiades K, Hanna S, Janus M, Georgiades S, … Thompson A. Language Impairment and Early Social Competence in Preschoolers with Autism Spectrum Disorders: A Comparison of DSM-5 Profiles. Journal of Autism and Developmental Disorders. 2014; 44(11): 2797–2808. DOI: 10.1007/s10803-014-2138-2 [PubMed: 24865586]

Bradshaw J, Steiner AM, Gengoux G, Koegel LK. Feasibility and effectiveness of very early intervention for infants at-risk for autism spectrum disorder: A systematic review. Journal of Autism and Developmental Disorders. 2014; doi: 10.1007/s10803-014-2235-2

Chawarska K, Paul R, Klin A, Hannigen S, Dichtel LE, Volkmar F. Parental recognition of developmental problems in toddlers with autism spectrum disorders. Journal of Autism and Developmental Disorders. 2007; 37(1):62–72. DOI: 10.1007/s10803-006-0330-8 [PubMed: 17195921]

Coonrod EE, Stone WL. Early concerns of parents of children with autistic and nonautistic disorders. Infants & Young Children. 2004; 17(3):258–268.

Davidson MM, Weismer SE. Characterization and prediction of early reading abilities in children on the autism spectrum. Journal of autism and developmental disorders. 2014; 44(4):828–845. [PubMed: 24022730]

Droucker D, Curtin S, Vouloumanos A. Linking infant-directed speech and face preferences to language outcomes in infants at risk for autism spectrum disorder. Journal of Speech, Language, and Hearing Research. 2013; 56:567.

Ellis Weismer, S. Intervention for children with developmental langauge delay. In: Bishop, DVM.; Leonard, LB., editors. Speech and language impairments in children: Causes, characteristics, intervention, and outcome. Psychology Press; 2000. p. 157-176.

Ellis Weismer S, Gernsbacher MA, Stronach S, Karasinski C, Eernisse ER, Venker CE, Sindberg H. Lexical and grammatical skills in toddlers on the autism spectrum compared to late talking toddlers. Journal of Autism and Developmental Disorders. 2011; 41:1065–1075. DOI: 10.1007/s10803-010-1134-4 [PubMed: 21061053]

Hedvall A, Westerlund J, Fernell E, Norrelgen F, Kjellmer L, Olsson MB, … Gillberg C. Preschoolers with autism spectrum disorder followed for 2 years: Those who gained and those who lost the most in terms of adaptive functioning outcome. Journal of Autism and Developmental Disorders. 2015; 45:1–10. DOI: 10.1007/s10803-015-2509-3 [PubMed: 25428291]

Herlihy L, Knoch K, Vibert B, Fein D. Parents' first concerns about toddlers with autism spectrum disorder: Effect of sibling status. Autism. 2013; 19:20–28. DOI: 10.1177/1362361313509731 [PubMed: 24216070]

Howlin P, Goode S, Hutton J, Rutter M. Adult outcome for children with autism. 2004; 2:212–229. http://dx.doi.org.offcampus.lib.washington.edu/10.1111/j.1469-7610.2004.00215.x.

Hus V, Taylor A, Lord C. Telescoping of caregiver report on the Autism Diagnostic Interview-Revised. Journal of Child Psychology and Psychiatry, and Allied Disciplines. 2011; 52(7):753–60. DOI: 10.1111/j.1469-7610.2011.02398.x

Ibanez, LV.; Stone, WL.; Coonrod, EE. Screening for autism in young children. In: Volkmar, FR.; Rogers, SJ.; Paul, R.; Pelphrey, KA., editors. Handbook of autism and pervasive developmental disorders, Volume 2: Assessment, interventions, and policy. New York: John Wiley & Sons, Inc; 2014. p. 585-608.

Johnson CP, Myers SM. Identification and evaluation of children with autism spectrum disorders. Pediatrics. 2007; 120(5):1183–1215. DOI: 10.1542/peds.2007-2361 [PubMed: 17967920]

Kenworthy L, Wallace GL, Powell K, Anselmo C, Martin A, Black DO. Early language milestones predict later language, but not autism symptoms in higher functioning children with autism spectrum disorders. Research in Autism Spectrum Disorders. 2012; 6(3):1194–1202. DOI: 10.1016/j.rasd.2012.03.009

Le Couteur, A.; Rutter, M.; Lord, C.; DiLavore, P. Toddler Research Diagnostic Interview-Revised. [Measurement instrument]. Los Angeles, CA: Western Psychological Services; 2006.

Lord, C.; Rutter, M.; DiLavore, P.; Risi, S. Autism diagnostic observation schedule (ADOS). Los Angeles: Western Psychological Services; 2002.

Lord C, Shulman C, DiLavore P. Regression and word loss in autistic spectrum disorders. Journal of Child Psychology and Psychiatry. 2004; 45(5):936–955. [PubMed: 15225337]

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 and Allied Disciplines. 2008; 49(11): 1184–1192. DOI: 10.1111/j.1469-7610.2008.01951.x

Luyster R, Gotham K, Guthrie W, Coffing M, Petrak R, Pierce K, … Lord C. 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 RJ, Seery A, Talbott MR, Tager-Flusberg H. Identifying early-risk markers and developmental trajectories for language impairment in neurodevelopmental disorders. Developmental Disabilities Research Reviews. 2011; 17(2):151–9. DOI: 10.1002/ddrr.1109 [PubMed: 23362034]

Mayo J, Chlebowski C, Fein DA, Eigsti IM. Age of first words predicts cognitive ability and adaptive skills in children with ASD. Journal of Autism and Developmental Disorders. 2013; 43(2):253–64. DOI: 10.1007/s10803-012-1558-0 [PubMed: 22673858]

Mullen, E. Mullen Scales of Early Learning. Circle Pines, MN: America Guidance Service; 1995.

Nadig AS, Ozonoff S, Young GS, Rozga A, Sigman M, Rogers SJ. A prospective study of response to name in infants at risk for autism. Archives of Pediatrics & Adolescent Medicine. 2007; 161:378–383. [PubMed: 17404135]

Naigles LR. Input and language development in children with autism. Seminars in Speech and Language. 2013; 34(4):237–48. DOI: 10.1055/s-0033-1353446 [PubMed: 24297616]

Paul, R. Predicting outcomes of early expressive language delay: Ethical implications. In: Bishop, DVM.; Leonard, LB., editors. Speech and language impairments in children: Causes, characteristics, intervention, and outcome. Psychology Press; 2000. p. 195-209.

Paul, R.; Ellis Weismer, S. When is late talking a matter for concern?. In: Rescorla, L.; Dale, P., editors. Late Talkers: Researcher to Practice. Baltimore, MD: Brookes Publishing; 2013.

Pierce K, Carter C, Weinfeld M, Desmond J, Hazin R, Bjork R, Gallagher N. Detecting, studying, and treating autism early: the one-year well-baby check-up approach. The Journal of Pediatrics. 2011; 159(3):458–465. e1–6. DOI: 10.1016/j.jpeds.2011.02.036 [PubMed: 21524759]

Rogers SJ, Vismara L, Wagner AL, McCormick C, Young G, Ozonoff S. Autism treatment in the first year of life: A pilot study of infant start, a parent-implemented intervention for symptomatic infants. Journal of Autism and Developmental Disorders. 2014; 44:2981–2995. DOI: 10.1007/s10803-014-2202-y [PubMed: 25212413]

Rucker DD, McShane BB, Preacher KJ. A researcher's guide to regression, discretization, and median splits of continuous variables. Journal of Consumer Psychology. 2015; 25:1–13. DOI: 10.1016/j.jcps.2015.04.004

Russell G, Miller LL, Ford T, Golding J. Assessing recall in mothers' retrospective reports: Concerns over children's speech and language development. Journal of abnormal child psychology. 2014; 42(5):825–830. DOI: 10.1007/s10802-013-9819-8 [PubMed: 24174265]

Rutter M. Autistic children: infancy to adulthood. Seminars in Psychiatry. 1970; 2:435–450. [PubMed: 5527410]

Rutter, M.; Le Couteur, A.; Lord, C. Autism diagnostic interview—revised. Los Angeles: Western Psychological Services; 2003.

Siller M, Sigman M. Modeling longitudinal change in the language abilities of children with autism: parent behaviors and child characteristics as predictors of change. Developmental Psychology. 2008; 44(6):1691–704. DOI: 10.1037/a0013771 [PubMed: 18999331]

Squires, J.; Bricker, D.; Potter, L. Ages & Stages Questionnaires, Third Edition (ASQ-3) User's Guide. Baltimore, MD: Paul H. Brookes Publishing; 2009.

Sparrow, SS.; Balla, D.; Cicchetti, D. Vineland adaptive behavior scales. Circle Pines, MN: American Guidance Service; 1984.

Sparrow, SS.; Cicchetti, DV.; Balla, DA. Vineland Adaptive Behavior Scales, Second Edition: Survey forms manual. Circle Pines, MN: AGS Publishing; 2005.

Tamis-LeMonda CS, Bornstein MH, Baumwell L. Maternal Responsiveness and Children's Achievement of Language Milestones. Child Development. 2001; 72(3):748–767. DOI: 10.1111/1467-8624.00313 [PubMed: 11405580]

Venker CE, Eernisse ER, Saffran JR, Weismer SE. Individual differences in the real-time comprehension of children with ASD. Autism Research. 2013; 6:417–432. DOI: 10.1002/aur.1304 [PubMed: 23696214]

Webb SJ, Jones EJH, Kelly J, Dawson G. The motivation for very early intervention for infants at high risk for autism spectrum disorders. International Journal of Speech-Language Pathology. 2014; 16(1):36–42. DOI: 10.3109/17549507.2013.861018 [PubMed: 24410019]

Wodka EL, Mathy P, Kalb L. Predictors of phrase and fluent speech in children with autism and severe language delay. Pediatrics. 2013; 131(4):e1128–e1134. [PubMed: 23460690]

Yoder P, Watson LR, Lambert W. Value-added predictors of expressive and receptive language growth in initially nonverbal preschoolers with autism spectrum disorders. Journal of Autism and Developmental Disorders. 2015; 45:1254–1270. DOI: 10.1007/s10803-014-2286-4 [PubMed: 25344152]

Zimmerman, IL.; Steiner, VG.; Pond, RE. Preschool Language Scale. 4. 2002. [Measurement instrument]. Pearson Assessment

Table 1

Participant Characteristics at Initial Assessment ($N = 98$)

Variable	Mean	(*SD*)	Range
Chronological age at interview	31.63	(4.51)	23 – 47
Autism symptom severity	7.38	(1.95)	1 – 10
Age of first words	19.49	(6.80)	7 – 37
Age of first phrases ($n = 30$)	28.67	(6.56)	10 – 45
Number of words ($n = 97$)	35.78	(39.13)	0 – 100
PLS-4 Standard Score ($n = 94$)			
Auditory comprehension	61.56	(13.30)	50 – 117
Expressive communication	74.71	(11.30)	50 – 110
MSEL VR T-score ($n = 76$)	37.04	(11.55)	20 – 68
VABS-II Composite ($n = 94$)	78.13	(7.49)	61 – 99

Note. Age and age-equivalent scores are given in months. PLS-4 = Preschool Language Scale, Fourth Edition (Zimmerman et al., 2002). MSEL VR = Mullen Scales of Early Learning Visual Reception subtest (Mullen, 1995). VABS-II = Vineland Adaptive Behavior Scales-II (Sparrow et al., 2005).

Table 2

Estimates for Age of First Words and Age of First Phrases as Predictors of Developmental Trajectories

	Receptive Language			Expressive Language			Nonverbal Cognition			Adaptive Behavior		
Fixed Effect	***β***	**SE**	***p***	***β***	**SE**	***p***	***β***	**SE**	***p***	***β***	**SE**	***p***
Age of First Words												
Intercept (mean)	69.17	1.89	< .001*	75.67	1.67	< .001*	40.28	1.20	<.001*	78.79	0.86	< .001*
Age of first words	−0.42	0.28	.137	−0.39	0.25	.118	−0.26	0.18	.147	−0.06	0.13	.624
Slope												
Age (rate of change)	0.62	0.07	< .001*	0.19	0.07	.010*	0.14	0.05	.009*	0.02	0.03	.340
Age of first words	< 0.01	.01	.921	< 0.01	0.01	.779	0.01	0.01	.312	0.01	< 0.01	.045*
Age of First Phrases												
Intercept (mean)	77.32	3.33	< .001*	84.89	2.53	< .001*	43.19	2.13	<.001*	84.02	1.30	< .001*
Age of first words	−0.62	0.64	.339	−1.06	0.48	.037*	−0.47	0.40	.252	−0.31	0.25	.228
Age of first phrases	−0.01	.71	.984	0.25	0.54	.648	0.29	0.46	.540	0.14	0.28	.607
Slope												
Age (rate of change)	0.76	0.11	< .001*	0.28	0.12	.025*	0.10	0.10	.328	−0.01	0.05	.789
Age of first words	−0.02	0.02	.465	−0.02	0.02	.396	<0.01	0.02	.876	<0.01	0.01	.951
Age of first phrases	−0.01	.02	.626	0.03	0.02	.197	<0.01	0.02	.916	0.01	0.01	.425

Note. Intercept reflects a chronological age of 45 months. All predictors were grand-mean centered.

Table 3

Estimates for Exploratory Predictor of Developmental Trajectories: Number of Words Produced

	Receptive Language			Expressive Language			Nonverbal Cognition			Adaptive Behavior		
Fixed Effect	***β***	**SE**	***p***	***β***	**SE**	***p***	***β***	**SE**	***p***	***β***	**SE**	***p***
Number of Words												
Intercept (mean)	69.33	1.77	< .001*	75.99	1.48	< .001*	40.41	1.18	< .001*	79.05	0.77	< .001*
Age of first words	−0.36	0.26	.171	−0.33	0.22	.131	−0.25	0.17	.163	−0.02	0.11	.834
Number of words	0.19	0.05	< .001*	0.20	0.04	< .001*	0.08	0.03	.011*	0.11	0.02	< .001*
Slope												
Age (rate of change)	0.61	0.07	< .001*	0.17	0.07	.021*	0.15	0.05	.006*	0.02	0.03	.516
Age of first words	<0.01	0.01	.980	<0.01	0.01	.762	<0.01	0.01	.611	0.01	<0.01	.044*
Number of words	<0.01	<0.01	.319	<0.01	<0.01	.214	<−0.01	<0.01	.237	<−0.01	<0.01	.037*

Note. Intercept reflects a chronological age of 45 months. All predictors were grand-mean centered.

J Autism Dev Disord. Author manuscript; available in PMC 2017 July 01.