Published in final edited form as:

J Child Psychol Psychiatry. 2015 January ; 56(1): 97–104. doi:10.1111/jcpp.12285.

Longitudinal study of symptom severity and language in minimally verbal children with autism

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Abstract

Background—A significant minority of children with autism spectrum disorder (ASD) are considered “minimally verbal” due to language development stagnating at a few words. Recent developments allow for the severity of ASD symptoms to be examined using Autism Diagnostic Observation Schedule (ADOS) Social Affect (SA) and Restricted and Repetitive Behaviors (RRB) domain severity scores. The aim of the current study was to explore language outcomes in a cohort of minimally verbal children with autism evaluated through the preschool years and determine if and how ASD symptom severity in core domains predicts the development of spoken language by age 5.

Methods—The sample consisted of 70 children with autism aged 1 to 5 years at the first evaluation who were examined at least one year later, during their fifth year of age. The ADOS overall level of language item was used to categorize children as minimally verbal or having phrase speech, and the Mullen Scales of Early Learning was used as a continuous measure of expressive language.

Results—At Time 1, 65% (n=47) of children in the sample were minimally verbal and by Time 2, 36% (n=17 of 47) of them had developed phrase speech. While the Time 1 ADOS calibrated severity scores did not predict whether or not a child remained minimally verbal at Time 2, change in the SA calibrated severity score (but not RRB) was predictive of the continuous measure of expressive language. However, change in SA severity no longer predicted continuous expressive language when nonverbal cognitive ability was added to the model.

Conclusions—Findings indicate that the severity of SA symptoms has some relationship to continuous language outcome, but not categorical. However, the omnipresent influence of nonverbal cognitive ability was confirmed in the current study, as the addition of it to the model rendered null the predictive utility of SA severity.

Introduction

The development of spoken language by age 5 has long been seen as a crucial milestone for predicting outcomes in children with autism spectrum disorder (ASD). Previous studies of

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Conflict of Interest Statement: The authors have no conflict of interest to declare.

ASD indicated that language development is predictive of outcomes related to independence (Gillberg & Steffenburg, 1987; Howlin, 2003). Testing the concept of a critical period for the development of language (Newport, 1991), recent data provide evidence that phrase speech is attained through at least age 8 in some children with ASD and severe language delay (Wodka, Mathy, & Kalb, 2013). However, other data suggest decreasing likelihood of phrase speech development beyond the age of 5 years. In a review of data from 78 children who developed speech at age 5 or older, 72% were age 7 or younger when at least single word speech developed (Pickett, Pullara, O'Grady, & Gordon, 2009). Only four children (out of 66 with adequate data) developed phrase speech after age 7.

Despite the growing literature on the importance of early language development for later outcomes in ASD (Mayo, Chlebowsky, Fein, & Eigsti, 2013), little is known about the factors that influence the development of language by age 5. In particular, a gap exists in understanding the impact of ASD symptom severity upon language development. The relationship between ASD symptoms and language development is particularly important for understanding why some children with ASD remain minimally verbal. Factors that contribute substantially may then be targeted to optimize interventions aimed at improving verbal abilities (Paul, Campbell, Gilbert, & Tsiouri, 2013; Tager-Flusberg & Kasari, 2013).

Determination of Minimally Verbal Status

Recent emphasis is placed on defining *functional speech* and on how this definition can be used to measure and categorize minimally verbal individuals. Five phases of language development have been outlined and described as benchmarks for use in childhood ASD research: preverbal communication, first words, word combinations, sentences, and complex language (Tager-Flusberg et al., 2009). The authors of these benchmarks note that it is critical to use several measures to determine a child's language phase. Further, the acquisition of language in multiple categories, including phonology, vocabulary and pragmatics, is required to meet criteria for each phase. In the current study, minimally verbal is defined as single words or less. Prior studies have taken varied approaches to quantifying expressive language, including the use of continuous variables such as age equivalents from language tests (Sigman & McGovern, 2005) and scores from the Vineland Adaptive Behavior Scales (Anderson et al., 2007). Some have also grouped samples into categories, using speech samples from measures such as the Autism Diagnostic Observation Schedule (Lord et al., 2000). It is important both to include observations of a child's language in making such categorizations (Kasari et al. 2013), and also to understand how these categories map onto scores from standardized language measures. Further, the use of categorical variables alone has several attendant limitations, including decreased statistical power, which may be exacerbated by the relatively small sample sizes used in studies of autism. While novel observation-based measures to objectively measure speech in naturalistic settings are under development (Dykstra et al., 2013), a goal of the current study was to examine measures frequently obtained in clinical assessment of children with ASD. To extend the field of minimally verbal children, an important first step is to utilize feasible methods for measuring minimally verbal status that are based on observation and easily tracked over time. In this case, the ADOS provides the context for the language sample, with trained raters quantifying speech into categories that capture minimally verbal status.

Predictors of Language Outcomes

A substantial body of research has examined predictors of spoken language in children with ASD, as well as in children with other delays and typical development. While there is some evidence for early verbal skills predicting later speech development in children with ASD (Stone & Yoder, 2001), nonverbal cognitive ability has been shown consistently to be a strong predictor of spoken language (Anderson et al., 2007; Charman et al., 2003). Other predictors of spoken language include various behaviors often impaired in ASD, including imitation (Stone & Yoder, 2001), joint attention (Mundy, Sigman, & Kasari, 1990), and the combination of these with play skills (Toth, Munson, Meltzoff, & Dawson, 2006). Because most observational measures of ASD symptom severity are heavily influenced by language level, very little is known about the predictive relationship between the general severity of ASD social-communicative and restricted and repetitive behavior symptoms and spoken language (Anderson et al., 2007).

With the recent development of ADOS Calibrated Severity Scores for overall symptom severity (Gotham, Pickles, & Lord, 2009) and the social affect and restricted and repetitive behavior core deficit domains it is now possible to explore the severity of core ASD symptom deficits in a model predicting language outcomes. Given that the severity of symptoms in these two core deficit domains is now an explicit part of the ASD diagnosis in the DSM-5 (American Psychiatric Association, 2013), it becomes even more important to understand how general severity of ASD relates both concurrently and longitudinally to the separate, but important diagnostic specifier, language impairment. It is particularly important to explore any predictive relationships between ASD severity in core domains and language development using measures that are frequently used clinically in assessing (and diagnosing) ASD. While very few psychometrically established measures quantify severity of ASD (Reszka, Boyd, McBee, Hume, & Odom, 2014), the ADOS was specifically chosen for use in the present study because it is widely used, has been studied extensively with respect to psychometric properties, and includes recently published (but not yet studied) severity scores that allow both domains of deficit to be quantified according to age and language level (Hus et al., 2012).

Therefore, the purposes of the present study were to: 1) examine the level of language development attained in a cohort of preschool-aged children with autism, with particular emphasis on describing children with minimal language development, 2) describe change in expressive language over time and predictors of that change, specifically nonverbal cognitive ability and autism symptom severity, and 3) given the known limitations of dichotomous variables, compare whether predictors differentially related to categorical versus dimensional language outcomes.

Methods

Participants

Informed consent was obtained for participants, who were part of a longitudinal study of autism approved by an NIH Institutional Review Board (ClinicalTrials.gov identifier NCT00298246), and were recruited from the community to participate in the longitudinal,

natural history study of autism, based on diagnosed or suspected ASD. Recruitment methods included medical providers and service and educational programs. Exclusionary criteria were cerebral palsy or unmanageable behavior problems. The sample comprised 70 children diagnosed with DSM-IV-TR Autistic Disorder ($n=57$, 81% male; $n=53$, 76% white; $n=66$, 94% non-Hispanic/Latino). Inclusion criteria were a diagnostic evaluation before the child turned 5 years and a follow-up evaluation at least 11 months later, between the ages of 4 years, 6 months and 6 years, 0 months (inclusive). The average age at initial evaluation (Time 1) was 3.56 ± 0.85 years (range 1.76–4.98); the average time to follow up (Time 2) was 1.90 ± 0.81 years (range 11 months to 3.6 years). The age range at follow up was 4.62–5.98 years, with a mean age of 5.45 ± 0.37 years.

Measures

The Autism Diagnostic Observation Schedule (ADOS) (Lord et al., 2000) is a semi-structured observational instrument used in ASD diagnostic evaluations. The ADOS consists of four published modules and a version of the ADOS developed for toddlers who were under the age of 30 months (Luyster et al., 2009). ADOS algorithms include both Social Affect (SA) and Restricted and Repetitive Behaviors (RRB) domains, with ADOS calibrated severity scores (CSS) now available both for total severity (Gotham et al., 2009) and SA and RRB domains (Hus et al., 2012). CSS for the SA (SA-CSS) and RRB (RRB-CSS) domains were explored as predictors and correlates of language level.

Based on spoken language used during the ADOS, children were classified into one of two language outcome categories: Minimally Verbal if they used no words or some single words, or Phrase Speech. Specifically, item A1 “Overall level of non-echoed spoken language” codes indicating no speech, single words, and occasional phrases were classified as Minimally Verbal, and “regular use of utterances with two or more words” (module 1), “speech is primarily two-or three word utterances, with minimal or no grammatical markings” (module 2), or any code on the language level A1 item on a module 3 were classified as Phrase Speech. All children in the Minimally Verbal group received the toddler version or module 1 of the ADOS at Time 1; and all but six children in the total sample received the toddler version or module 1 (six children received ADOS module 2).

The Mullen Scales of Early Learning (MSEL) (Mullen, 1995) measures development in five areas: Gross Motor, Visual Reception, Fine Motor, Receptive Language, and Expressive Language. Developmental Quotients (DQ; age equivalents divided by chronological age multiplied by 100), were used for all children to accommodate those outside the age range of the MSEL (birth to 68 months) and to account for floor effects in children with very low raw scores. MSEL Nonverbal (NV; comprised of the average of the Visual Reception and Fine Motor areas) and Verbal (V; comprised of the average of the Receptive Language and Expressive Language areas) DQs, as well as the expressive language age equivalent (AE) subscale score, were included in analyses.

Procedure

Autism diagnosis was established at Time 1 by best estimate clinical judgment of doctoral-level clinicians, using DSM-IV-TR criteria, the Autism Diagnostic Interview-Revised (ADI-

R) (Rutter, 2003), and the ADOS. All children completed a follow-up evaluation (Time 2). The MSEL and ADOS were completed at both time points.

Analyses

Logistic regression was used to examine the categorical language outcome (Minimally Verbal versus Phrase Speech) at Time 2 and linear regression was used for the dimensional language outcome (MSEL Expressive Language age equivalent). Alpha was .05. All analyses were completed in SPSS Version 21.0 (IBM Corp., 2012).

Results

Language Acquisition

Sixty-seven percent ($n=47$) of the sample ($n=70$) was classified as Minimally Verbal at Time 1. In the full sample ($n=70$), the Time 1 mean NVDQ and VDQ scores were 64.6 ± 15.8 and 46.6 ± 20.1 , respectively. At Time 1, MSEL Expressive Language AE in the full sample was 18.90 ± 10.19 months. Table 1 shows the Time 1, Time 2, and change scores on the MSEL and ADOS for children classified as Minimally Verbal at both time points, Minimally Verbal moving to Phrase Speech, and Phrase Speech at both time points. While scores on the MSEL differed significantly between the Minimally Verbal and Phrase Speech groups at Time 1 (see Table 1), no significant differences between groups were observed on ADOS SA- or RRB-CSS.

The correspondence between categorical language measurement (Minimally Verbal versus Phrase Speech) and dimensional measurement (MSEL Expressive Language AE) is shown in Figure 1. Considering whether or not the child was minimally verbal at each timepoint (i.e., collapsing the first two bars for Time 1 and the second two bars for Time 2), MSEL Expressive Language was strongly related to language status (point-biserial $r=.84$, and $r=.81$ at Time 1 and Time 2, respectively). Figure 1 also shows the distribution of MSEL Expressive Language AE within those children who were Minimally Verbal at both time points, those who moved from Minimally Verbal to Phrase Speech, and those who had Phrase Speech at both time points. As demonstrated in Table 1, the children who would go on to develop phrase speech had significantly higher Expressive Language AEs at Time 1 than those who would remain minimally verbal.

At Time 2, 43% of the sample ($n=30$ of 70) was Minimally Verbal. Thus, less than half ($n=17$ of 47, 36%) of the Time 1 Minimally Verbal group moved into the Phrase Speech group at Time 2. The movement between ADOS item A1 scores at Time 1 and Time 2, used to generate the Minimally Verbal designation, is shown in Figure 2. As shown, 23 children (33%) were in the Phrase Speech group at both time points. Five children (7%) had no words at both time points and 14 children (20%) had single words at both time points. The remainder moved about between categories, including one child who decreased from some words at Time 1 to no words at Time 2 (this child received Module 1 at both time points and MSEL Expressive Language AE decreased from 22 months to 13 months).

Predictors of Development of Phrase Speech at Time 2

The remainder of analyses focuses on the Time 1 Minimally Verbal subgroup ($n=47$). In order to aid interpretation of subsequent regression analyses, the intercorrelations among putative predictors were explored. At both Time 1 and Time 2, significant correlations were observed between contemporaneous NVDQ and VDQ ($r = .62, p < .001$; $r = .89, p < .001$, respectively). At Time 1, neither NVDQ nor VDQ correlated with ADOS SA-CSS or RRB-CSS. At Time 2, both NVDQ and VDQ correlated with ADOS SA-CSS ($r = -.41, p = .004$; $r = -.33, p = .02$; respectively). Neither DQ score correlated with ADOS RRB-CSS at Time 2. ADOS RRB- and SA-CSS did not correlate significantly with one another at either time point.

Chronological age at Time 1 and time-to-follow-up were not related to language status at Time 2 and were therefore excluded from further analyses of predictors. The results of the logistic regressions predicting Minimally Verbal versus Phrase Speech at Time 2 are presented in Table 2. Time 1 VDQ failed to reach statistical significance as a predictor of Phrase Speech at Time 2 ($OR = 1.03, p = .15$). However, inspection of the data revealed one Time 1 VDQ outlier (who was also the lone participant to move from some words to no words on ADOS item A1), and the removal of this outlier from this analysis yielded a statistically significant result of the same magnitude ($OR = 1.03, p = .048$). Percent change in VDQ between Time 1 and Time 2 was also significantly related to Time 2 language status, such that each percentage increase in VDQ conferred a 3% increase in the odds of moving into Phrase Speech at Time 2 ($OR = 1.03, p = .003$; results did not change when the outlier was excluded). The VDQ outlier did not affect the remainder of the analyses, so data from this participant was retained in subsequent analyses. Both NVDQ at Time 1 ($OR = 1.05, p = .049$) and percent change in NVDQ ($OR = 1.07, p = .003$) were significant predictors of Phrase Speech at Time 2.

The Time 1 ADOS domain CSS did not predict language status at Time 2, even after controlling for NVDQ. Nor was change in the ADOS SA- and RRB-CSS related to Time 2 language status.

Analyses were repeated using MSEL Expressive Language AE as the outcome variable in a linear regression (Table 2). Prior to conducting the regression analyses, the relationship between chronological age at Time 2 and the predictor variables was tested to rule out chronological age as a possible confound; none of the correlations were significant. Time 1 NVDQ and VDQ as measured by the MSEL both emerged as significant predictors of Time 2 MSEL Expressive Language AE ($B = 0.38, p < .001$; $B = 0.30, p = .008$, respectively). Percent improvement in NVDQ and VDQ significantly predicted MSEL Expressive Language AE at Time 2 ($B = 0.27, p < .001$; $B = 0.17, p < .001$, respectively). Improvement in ADOS SA-CSS significantly predicted higher MSEL Expressive Language AE at Time 2 ($B = -1.82, p = .049$). When NVDQ was added to this model, however, improvement in SA-CSS no longer significantly predicted MSEL Expressive Language AE at Time 2 ($B = -0.37, p = .48$; $B = -1.41, p = .10$, respectively).

Discussion

Recently, great emphasis has been placed on the need for study of children with autism who remain minimally verbal into the school-age years (Tager-Flusberg & Kasari, 2013). In this longitudinal study, we evaluated autism symptom severity as a predictor of membership in this understudied subgroup of children classified as minimally verbal at age 5. Further, using the newly available metrics of ADOS score severity, we also assessed the relationship between autism severity and a dimensional measure of verbal ability.

Language Benchmark Change from Preschool to School-age

We found that out of 70 preschool-aged children with autism, only 33% of the sample had achieved phrase speech at Time 1 (at a mean age of 3.6 years). While some children developed words and phrases by Time 2 (mean age 5.5 years), a significant proportion of children (43%) remained minimally verbal. This proportion is similar to the results of a study that used only the ADOS module administered or caregiver response to the ADI-R language level question, wherein 52% of children with autism were not using consistent phrase speech at age 9 and of these, 29% had at most a few consistent words (Anderson et al., 2007). However, given the young age of the current sample, some caution should be used in generalizing the rates of minimally verbal status from the current study. Anderson et al. and most other recent studies have based estimates of verbal status on older children (Wodka et al., 2013), and as evidenced by Pickett et al. (2009), some children may still develop language. Further, the current study included only children with DSM-IV diagnosed autistic disorder, and previous studies indicate that children previously diagnosed with PDD-NOS had lower rates of minimally verbal status (Anderson et al. 2007).

Importantly, given that there is not yet an established operationalized definition for minimally verbal, results from the current study are not wholly comparable with findings from previous studies. The present study utilized observations by trained ADOS coders (as opposed to ADOS module administered), with minimally verbal status defined as codes less than “regular use of utterances with two or more words” on the established ADOS coding. This classification was strongly related to MSEL Expressive Language age equivalent, with a cutoff of about 18 months, though there was some overlap between Minimally Verbal and Phrase Speech groups. This ADOS-based definition falls between the two categories used by Anderson et al. (described above). Thus, the 43% of children that were minimally verbal at Time 2 is consistent with other studies and should not be confused with rates that use at most “some words” as their definition (Tager-Flusberg & Kasari, 2013).

As expected, children remaining minimally verbal at age 5 differed at both Time 1 and Time 2 on expressive language scores on the MSEL. Age equivalents for minimally verbal children at both time points averaged about 12 months (before phrase speech is typically developed), compared to the average expressive language level increase from approximately 15 months to over 30 months in children who were Minimally Verbal at Time 1 but developed phrase speech. Although the group of children who moved from Minimally Verbal to Phrase Speech did not “catch up” in expressive language to those children who had already acquired Phrase Speech at Time 1 (whose age equivalents were over 3 years by

Time 2), these children made on average over 15 months of progress in expressive language in a time period that averaged a bit less than 2 years.

However, it is important to note that there was some overlap of MSEL Expressive Language scores between the Minimally Verbal and Phrase Speech groups. Some children with observed phrase speech on the ADOS had a MSEL expressive language age equivalent lower than 12 months at age 5. Conversely, the maximum age equivalent for a child categorized as minimally verbal at age 5 was 22 months. As may be predicted for children with ASD, this trend indicated underestimated language abilities in children who were observed to use phrase speech, rather than overestimated language abilities of minimally verbal children. The direction of this trend may be explained by the general difficulty of engaging in standardized testing for many children with ASD (versus the more naturalistic setting of the ADOS) (Rapin, 2003). Thus, this study demonstrates that the minimally verbal versus phrase speech designation does not correspond neatly to a given score on a standardized assessment. These findings lend support for use of multiple measures in corroborating and designating a child's language status.

Predictors of Change in Language Level over Time

The identification of predictors for remaining nonverbal at age 5 is important for the development of targeted intervention. The results of this study corroborate existing data (Anderson et al., 2007; Charman et al., 2003; Thurm, Lord, Lee, & Newschaffer, 2007) in showing that higher verbal and nonverbal developmental level in the preschool years, as well as improvement in verbal and nonverbal developmental level, predicted the development of phrase speech by school-age. The primary contribution of this study was to explore the predictive power of autism symptom severity for the development of phrase speech by age 5 in children who were minimally verbal in the preschool years. Heretofore, this sort of exercise was precluded by lack of adequate measurement tools for autism severity, leading researchers to focus on specific deficits in skills or abilities (e.g., joint attention). The ADOS CSS were created in part to reduce the influence of secondary impairments (e.g., language skills, cognitive level) on the measurement of autism symptom severity, allowing researchers to more accurately examine the relationship between autism severity and language development. With the recent separation of CSS for social impairments and restricted and repetitive behaviors, we were able to examine the two domains independently.

Neither CSS score was related to the later development of phrase speech in children who were minimally verbal at Time 1 and dichotomized as either minimally verbal or phrase speech at Time 2. However, change in SA-CSS was associated with dimensional language outcome (MSEL Expressive Language age equivalent). This is consistent with previous findings from a retrospective study that reported lower social impairment on the ADI-R was related to the development of verbal skills (Wodka et al., 2013). It is important to note, however, that in the present study, change in SA-CSS no longer predicted expressive language at Time 2 when Time 1 nonverbal cognitive ability was added to the model. While it was encouraging that the SA-CSS was not significantly correlated with either VDQ or NVDQ at Time 1, the significant correlations of VDQ and NVDQ with SA-CSS at Time 2

may indicate that collinearity of nonverbal cognitive ability and SA-CSS (at least with respect to change scores) may compromise the ability to accurately assess predictive models of language acquisition in ASD.

The source of this collinearity is worth considering. This relationship is most likely bi-directional; greater symptoms of autism may be related to difficulty in performing the tasks required by a cognitive test, but lower cognitive skills may also be responsible for stronger presentation of autism symptoms. This bi-directional relationship is likely evidenced in general learning of verbal (and other) abilities at school and in other intervention and learning contexts.

The discrepant results between dichotomous and continuous outcomes in this study underscore the axiomatic limitations (i.e. a loss of statistical power) of categorical variables such as minimally verbal versus phrase speech. In fact, it is difficult to ascertain whether the lack of statistical power due to a smaller sample size in the current study explains why the use of categorical groupings of language outcome failed to replicate the findings of the large (n=535) retrospective study by Wodka et al. (2013), which also used categorical outcomes. That the current study replicated these findings using only the continuous measure and not the categorical measure serves as a reminder that continuous variables are important to consider in addition to categorical outcomes, particularly when sample sizes are not large. In addition, specific characteristics of the sample, such as age and functioning level, may be critical, as the current findings differed from a study of even younger, but less cognitively delayed children, in which restrictive and repetitive behavior related to language development (Paul, Chawarska, Cicchetti, & Volkmar, 2008).

Limitations

As stated earlier with respect to generalizing rate of minimally verbal children with ASD, this sample may not be representative of the broader ASD population, as only children with DSM-IV autistic disorder were enrolled. Further, as all non-epidemiological research runs the risk of recruiting biased samples, families of young children who were willing to participate in a longitudinal study may differ in important ways from families who did not participate. Larger community-based studies are necessary to obtain the true prevalence of minimally verbal status in the ASD population.

While not a limitation per se, it should be noted that the current study only includes domain and total severity scores as predictors, rather than more specific symptoms of ASD or hypothesized precursors to expressive language development. Specific symptoms and deficits certainly have been shown to be important for predicting language development in minimally verbal children; one recent study showed that behaviors such as joint attention moderated the response to targeted treatment for improving language in minimally verbal children (Paul et al., 2013).

Clinical Implications and Future Directions

This study adds to the literature by showing longitudinal change in language developmental in preschool children who were minimally verbal. It adds to the considerable literature implicating nonverbal cognitive abilities in the development of spoken language in ASD,

and iterates the importance of interventions focused on the development of basic nonverbal cognitive skills as one mechanism of enhancing language outcomes in children with ASD. The finding that the severity of autism symptom domains was not associated with the development of phrase speech per se between preschool and school-age years implies that although improvement in core symptoms of ASD remains a crucial treatment goal for all children, lack of such improvement may not necessarily interfere with the development of phrase speech. Still, the improvement in social affect symptoms did predict improvement in a continuous measure of expressive language (when nonverbal cognitive ability was not in the model), even if children did not acquire phrase speech. Thus, the results of this study emphasize the influence of some symptoms of ASD upon language development, but also highlight the even stronger influence of nonverbal cognitive abilities. Future longitudinal studies that follow children over longer periods of time and include a wider range of severity scores will be important in continuing to explore the impact of core symptoms of ASD on which children remain minimally verbal.

Acknowledgments

We thank the families that dedicated their time to make this research happen, as well as the many members of the Pediatrics and Developmental Neuroscience Branch that contributed to this research. This research was supported by the Intramural Program of the National Institute of Mental Health.. Protocol number 06-M-0102 and NCT00298246.

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Key Points

- We confirmed previous reports that a substantial proportion of children with autism remain “minimally verbal” (e.g., without phrase speech) at age 5.predictive relationships.
- A substantial number of children moved from minimally verbal to phrase speech from the preschool years to age 5.predictive relationships.
- Using recently created severity scores for the core deficits of ASD, we showed that while improvement in social affect severity was related to a continuous measurement of expressive language, this effect was accounted for by nonverbal cognitive ability.predictive relationships.
- The use of a categorical “minimally verbal” outcome rather than a continuous measure may limit the ability of a study to find predictive relationships.

Figure 1.

The correspondence between categorical language measurement (Minimally Verbal versus Phrase Speech) and dimensional measurements (MSEL Expressive Language age equivalent) at Time 1 and Time 2.

Note: MV/MV=children who were Minimally Verbal at both timepoints ($n=30$); MV/PS=children who were Minimally Verbal at Time 1 and had Phrase Speech at Time 2 ($n=17$); PS/PS=children who had Phrase Speech at both time points ($n=23$). All groups were

significantly different from one another at both time points (see Table 1). The groups did not differ in chronological age at either time point (see Table 1).

Figure 2.

Change over time in ADOS language level

Note: Age at Time 1 was 3.56 ± 0.85 years (range 1.76–4.98). Age at Time 2 was 5.45 ± 0.37 years (range 5.45–5.82).

Table 1

Participant Descriptives

	MV/MV	MV/PS	PS/PS	Omnibus F (p)	Post-Hoc
n	30	17	23		
Time 1					
Age (Years)	3.45 ± 0.88	3.42 ± 0.93	3.79 ± 0.71	1.34 (.27)	
NVDQ	56.33 ± 12.57	65.17 ± 15.40	75.01 ± 13.92	12.06 (<.001)	1<2, 1<3, 2<3
VDQ	34.51 ± 14.48	40.97 ± 12.94	66.66 ± 15.14	34.43 (<.001)	1<3, 2<3
Expressive AE	11.73 ± 4.84	15.41 ± 5.33	31.36 ± 6.01	90.04 (<.001)	1<2, 1<3, 2<3
SA-CSS	6.87 ± 1.31	6.94 ± 1.95	6.65 ± 0.93	0.24 (0.78)	
RRB-CSS	8.63 ± 1.27	8.19 ± 1.56	7.87 ± 1.98	1.51 (0.23)	
Time 2					
Age (Years)	5.44 ± 0.36	5.46 ± 0.39	5.46 ± 0.39	0.02 (.98)	
Time-to-Follow-Up (Years)	1.99 ± 0.87	2.04 ± 0.83	1.67 ± 0.69	1.41 (.25)	
NVDQ	40.38 ± 7.81	61.82 ± 18.89	76.05 ± 18.77	37.46 (<.001)	1<2, 1<3, 2<3
VDQ	25.94 ± 8.94	52.68 ± 21.12	63.28 ± 17.08	41.32 (<.001)	1<2, 1<3, 2<3
Expressive AE	13.70 ± 5.47	31.00 ± 9.88	37.76 ± 7.46	72.59 (<.001)	1<2, 1<3, 2<3
SA-CSS	7.40 ± 1.40	6.76 ± 2.22	7.17 ± 1.67	0.74 (0.48)	
RRB-CSS	8.20 ± 1.47	7.76 ± 1.30	8.00 ± 1.45	0.51 (0.6)	
Change (T2-T1)					
NVDQ	-0.26 ± 0.17	-0.04 ± 0.20	0.03 ± 0.26	13.35 (<.001)	1<2, 1<3
VDQ	-18.70 ± 33.91	33.68 ± 51.67	-4.74 ± 15.51	12.42 (<.001)	1<2, 2>3
SA-CSS	0.53 ± 1.55	-0.31 ± 2.02	0.52 ± 1.78	1.43 (0.25)	
RRB-CSS	-0.43 ± 1.83	-0.44 ± 1.75	0.13 ± 2.32	0.62 (0.54)	

Note: MV/MV = Minimally Verbal at Time 1 and Time 2; MV/PS = Minimally Verbal at Time 1 and Phrase Speech at Time 2; PS/PS = Phrase Speech at Time 1 and Time 2. Post-hoc tests refer to significant pairwise comparisons (LSD; $p < .05$): 1 = MV/MV, 2 = MV/PS, 3 = PS/PS.

Table 2

Predictors of Attaining Phrase Speech by Time 2 in Minimally Verbal Children at Time 1 (n=47)

	Logistic regression predicting Phrase Speech (versus Minimally Verbal) at Time 2			Linear regression predicting MSEL Expressive Language Age Equivalent at Time 2		
	B (SE)	95% CI for OR	p	B (SE)	95% CI for B	t(p)
Time 1VDQ	0.03 (0.02)	(0.99, 1.08)	.15 ¹	0.30 (0.11)	(0.08, 0.51)	2.77 (.008)
% Change in VDQ	0.03 (0.01)	(1.01, 1.05)	.003	0.18 (0.03)	(0.13, 0.23)	6.92 (<.001)
Time 1 NVDQ	0.05 (0.03)	(1.00, 1.10)	.049	0.38 (0.10)	(0.18, 0.59)	3.72 (.001)
% Change in NVDQ	0.07 (0.02)	(1.02, 1.12)	.003	0.27 (0.07)	(0.13, 0.42)	3.86 (<.001)
Time 1 ADOS SA-CSS	0.03 (0.20)	(0.69, 1.54)	.88	-1.28 (1.09)	(-3.48, 0.91)	-1.18 (.25)
Time 1 ADOS RRB-CSS	-0.24 (0.23)	(0.50, 1.23)	.30	-1.92 (1.14)	(-4.22, 0.38)	-1.68 (.10)
Change in SA-CSS	-0.29 (0.19)	(0.52, 1.08)	.12	-1.82 (0.90)	(-3.64, -0.008)	-2.03 (.049)
Change in RRB-CSS	-0.001 (0.18)	(0.71, 1.41)	.99	-0.07 (0.91)	(-1.91, 1.77)	-0.77 (.94)

¹The removal of a Time 1 VDO outlier yielded a significant result (B= 0.06, p= .048) for logistic regression predicting Phrase Speech at Time 2.

Note: Age and time-to-follow-up were not associated with outcome and were therefore excluded from the models.