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A Longitudinal Analysis of Expressive Language Trajectories in Autistic Individuals and the Influence of Receptive Language

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy in Education

by

Katherine Byrne

2026

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ABSTRACT OF THE DISSERTATION

A Longitudinal Analysis of Expressive Language Trajectories in Autistic Individuals and the Influence of Receptive Language

by

Katherine Byrne

Doctor of Philosophy in Education

University of California, Los Angeles, 2026

Professor Catherine Lord, Chair

There is considerable heterogeneity in the expressive language development of autistic individuals across the lifespan. Some children score in the average (or even above average) range on language or vocabulary tests but exhibit more nuanced or subtle semantic and pragmatic language difficulties. At the other end of the continuum, a significant subset of the autistic population – estimated at around 30% – do not acquire functional expressive language, even after intensive interventions. Another approximately 40% of autistic individuals fall somewhere in between these endpoints. The heterogeneity in rate of language development and linguistic outcomes is not well understood. Furthermore, variable methods of expressive language measurement have complicated comparisons across autistic samples. The current study characterized trajectories of expressive language from ages 2 to 25 years and analyzed the

influence of receptive language (as opposed to aspects of nonverbal cognition, such as nonverbal problem solving or fine motor skills, which have been widely studied) on these trajectories. Group based trajectory modeling revealed five distinct expressive language trajectory classes best characterized as: Stable No Words, Stable Single Words, Phrase Speech Never Complex, Early Catch-Up, and Stable High-Language. Multinomial logistic regression using the Stable High Language group as the reference group revealed that higher receptive language raw scores were associated with a significantly lower likelihood of belonging to all four alternative expressive language trajectories, even after controlling for age and symptom severity. Language growth slowed after age 5 years and plateaued around age 9 years. Results confirmed the immense heterogeneity in expressive language of autistic individuals across time. Furthermore, results point to the use of receptive language as a potentially important intervention target within language interventions. Finally, the use of a valid, well-established observational measure commonly used in autism research, the ADOS, to characterize the complexity of expressive language use in a semi-structured and naturalistic way allowed for better comparison of fine-grained language abilities across samples, thereby fostering increased consistency within autism research.

The dissertation of Katherine Byrne is approved.

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University of California, Los Angeles

2026

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1. **Byrne, K.** (2022, May). *Extending the Usefulness of the Brief Observation of Social Communication Change: BOSCC- PSYF*. Presented at the UCLA Center for Autism Research and Treatment General & Executive Meeting, UCLA, Los Angeles, CA, USA.
2. Holbrook, A., Dow, D., Kim, S H., Toolan, C., **Byrne, K.,** Grzadzinski, R., Sterrett, K., Lord, C. (2020, June). *Brief Observation of Symptoms of Autism (BOSA) Training.* Presented via telehealth through the Center for Autism Research and Treatment (CART), UCLA, Los Angeles, CA, USA.

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Introduction

Autism spectrum disorder (ASD) is a complex neurodevelopmental disorder characterized by 1) deficits in social communication and interactions and 2) the presence of restricted and repetitive interests and patterns of behavior (American Psychiatric Association, 2022). Clinical phenotypes and outcomes within the autism spectrum are incredibly varied. Autistic individuals present with heterogeneous presentations across many domains including core autism symptoms, cognitive ability, adaptive skills, co-occurring conditions, and language level (Lombardo et al., 2019; Lord, Charman, Havdahl, Carbone, Anagnostou, Boyd, Carr, Vries, et al., 2022). Language delay is no longer a requisite for an autism diagnosis in the most recent version of the Diagnostic and Statistical Manual (DSM-5; American Psychiatric Association, 2013). Nonetheless, language delays manifest in the majority of autistic individuals (Pickles et al., 2014).

Autism and Language

Delayed language is frequently cited by caregivers as the first sign of atypical development or a potential autism diagnosis (Becerra-Culqui et al., 2018). One infant sibling study demonstrated that, as early as 9 months of age, almost 20% of parents of infants at high-risk for autism (based on having a sibling diagnosed with autism) reported notable concerns regarding their child's language (Tran et al., 2021). In the first year of life, very young children who go on to receive an autism diagnosis are less likely to vocalize (Chenausky et al., 2017) and babble canonically (Yankowitz et al., 2022) compared to those without autism.

Research has also demonstrated differences in the pre-speech sound patterns of infants at high risk for autism. For example, one study demonstrated that infants at high-risk for autism demonstrated similar vocalization frequency as infants without elevated risk, but produced more

"non-speech" vocalizations, less frequent canonical syllables, and fewer consonants (Paul et al., 2010). Another study demonstrated lower volubility and a higher rate of nondirected vocalizations in infants at risk for autism as compared to a non-ASD control group (Garrido et al., 2017). This is important to consider given intentionality and directedness of communication in high-risk infants is associated with more advanced expressive language less than one year later (Markfeld et al., 2025).

Within the framework of developmental cascades, early language delays and differences are hypothesized to set off a chain of direct and indirect negative downstream effects not only on the developing communication system itself but also across other areas of development (Iverson, 2021; Masten & Cicchetti, 2010). These negative cascading effects on communication are critical to recognize, as earlier use of words and phrases is predictive of better cognitive, linguistic and adaptive outcome years later (Kover et al., 2016; Mayo et al., 2013). Thus, early language delays and differences may interfere with the timely acquisition of words and phrases, disrupting critical foundations of communication development in ways that may negatively impact later adaptive functioning.

Developing language by age 5 years has been extensively studied and consistently emerges as one of the most important indicators of positive prognosis in autistic individuals (Howlin et al., 2004). Specifically, early language use has been shown to be predictive of better adaptive functioning, academic achievement, well-being, vocational independence, and participation in successful social interactions in autistic populations (Friedman et al., 2019; Gillespie-Lynch et al., 2012; Magiati et al., 2014). The ways in which "language" has been defined across research studies, however, is highly variable. As such, the use of specific linguistic milestones has been proposed as potentially useful indicators of characterization and

prognosis (Bal et al., 2020; Kenworthy et al., 2012; Kover et al., 2016; Tager-Flusberg et al., 2009).

Linguistic milestone attainment—including the transition from single words to two to three word phrases and from phrases to more complex language—is understudied in autistic populations (Byrne et al., 2024). Existing research has largely focused on nonspeaking or minimally speaking autistic individuals (Pickett et al., 2009; Saul et al., 2026). Yet a substantial proportion of autistic individuals fall between the endpoints of minimally speaking and fluent speech. The developmental pathways within this intermediate range of spoken language remain poorly characterized and little is known about how to best support the language growth of individuals who have "some" speech.

Heterogeneity of Profiles and Trajectories

While early language delays are evident in the majority of autistic individuals, linguistic profiles are heterogeneous both between autistic individuals and within an autistic person across development. Some children score in the average (or even above average) range on language or vocabulary tests, but exhibit more nuanced or subtle semantic and pragmatic language difficulties (Boucher, 2012; Ellis Weismer & Kover, 2015; Luyster et al., 2022). For example, research has demonstrated that verbal autistic individuals have greater difficulty in maintaining reciprocal conversations compared to nonautistic peers as evidenced by fewer initiations of conversational turns and greater amounts of nonresponses (Martin et al., 2018). A recent study including three-year-old verbal children found that those who went on to receive an autism diagnosis were less likely to offer new information in conversations during play as compared to children at an elevated risk for autism without a diagnosis, those at an elevated risk who received

a diagnosis of language delay without autism, and those at no elevated risk for autism (Britsch & Iverson, 2024).

At the other end of the continuum, a significant subset of the autistic population – estimated at around 30% – do not acquire functional expressive language, even after intensive interventions (Bal et al., 2020; Pickles et al., 2014; Tager-Flusberg & Kasari, 2013; Vivanti et al., 2025). Little is known about why these individuals never develop spoken language. While co-occurring speech and language disorders, such as apraxia of speech, may be present in some of the minimally verbal population, these conditions likely present in only a relatively small subset of individuals (Chenausky et al., 2019; Shriberg et al., 2011). Other theories that have been proposed include deficits in motor imitation (Sandbank et al., 2017; Vivanti et al., 2025) and joint attention (i.e., the purposeful coordination of attention with that of another person; Iao et al., 2024), among others.

Even among the children who develop some language, there is variability in the rate at which language progresses (Broome et al., 2023; Saul & Norbury, 2020). However, longitudinal data is limited. Within a longitudinal sample of 192 participants across 18 years (an overlapping sample to that of the current study), Pickles and colleagues (2014) identified seven distinct latent trajectory classes based on parent-reported combined expressive and receptive language scores. Between the ages of 2 to 5 years, all seven classes showed considerable heterogeneity, with a substantial minority demonstrating rapid language growth and over 50% demonstrating marked delays in language that persisted over time. Only 5% of these participants displayed “near typical” language development. After age 5, all classes tracked in parallel. This finding suggests less malleability and more linearity in language growth after the age of 5. More long-term

longitudinal research is needed to elucidate potential linguistic subgroups within the autistic population.

Predictors of Language Acquisition

Much work has been done to identify predictors of expressive language growth and outcomes in autistic samples. Across both cross-sectional and longitudinal studies, early social skills such as joint attention (Adamson et al., 2019; Frost et al., 2022; Kissine et al., 2023), imitation (Chenausky et al., 2018; Iao et al., 2023; Thurm et al., 2007; Wang et al., 2021), play (Paul et al., 2008; Pecukonis et al., 2019), and social motivation (Su et al., 2020) have emerged as consistent predictors of language acquisition in autistic children.

Gesture use has also been identified as predicting language outcome in autism (Luyster et al., 2008; Ozcaliskan et al., 2017). A systematic review identified 13 studies which examined the predictive power of gestures on later language use in autism; only two found no association (Kilili-Lesta et al., 2022). One recent study analyzed gestural communication in minimally verbal children and adolescents and found that supplementary gesture-speech combinations, or those that add information not provided by the gesture alone (e.g., point to a cookie + "more"), uniquely predicted amount of speech and number of different words used approximately 4 months later (La Valle et al., 2024).

A robust association has also been established between language and cognition (Anderson et al., 2007; Chetcuti et al., 2025; Mouga et al., 2020; Norrelgen et al., 2015). In particular, nonverbal IQ has been shown to be a significant predictor of expressive language growth and outcome (Byrne et al., 2024; Ellis Weismer & Kover, 2015). One study identified nonverbal cognition at age 2 years as the strongest predictor of language outcome at 5 years (Thurm et al., 2007). Another study which included 535 older autistic children (mean age approximately 11

years) with language delay (defined as not acquiring phrase speech before age 4 years) found that higher nonverbal IQ was associated with attainment of phrase speech and earlier age at acquisition (Wodka et al., 2013).

Unsurprisingly, early language skills also emerge as a significant predictor of later language use (Thurm et al., 2007). Research has demonstrated that earlier age of parent reported linguistic milestone attainment predicts better standardized scores of expressive language (Mayo et al., 2013), structural language abilities (Kenworthy et al., 2012), and trajectories of expressive language (Kover et al., 2016). Yoder and colleagues (2015) reported that consonant inventory and intentional communicative acts were predictive of expressive language growth 16 months later in preverbal, autistic preschool-aged children. Similarly, Saul & Norbury (2020) found that consonant inventory and phonetic repertoire in preverbal, autistic preschool children were predictive of language outcome one year later. Both studies suggest that initial speech skills play a key role in language development in autism. However, relatively little research has explored how different domains of language predict each other – such as the extent to which receptive language skills predict the development of expressive language.

Influence of Receptive Language

In typical development, receptive language is believed to be a foundational skill to the development of expressive language. Children first comprehend words, usually the bids of caregivers, before their production of first words. Seminal work in this area has elucidated that the receptive vocabulary of typically developing infants often pertains to games and routines (e.g., peekaboo, bath, bye), people in the infants' lives (e.g., mommy, daddy, and child's own name), and highly familiar objects (Fenson et al., 1994). Expressive vocabulary, on the other hand, usually begins around age 12 months and also most frequently pertains to familiar people,

games and routines (Fenson et al., 1994). Furthermore, research has demonstrated that receptive language is predictive of expressive language growth in late-talking typically developing toddlers (Fisher, 2017).

Theories have proposed a transactional nature between receptive and expressive language suggesting that a child's verbal communication elicits a richer linguistic environment. These social and linguistic opportunities from caregivers in the child's language environment, in turn, bolster receptive language skills which provides the basis for further development of expressive language (Camarata & Yoder, 2002; Su et al., 2021). While it is known that both comprehension and expression are delayed in a majority of autistic individuals, much less research has been conducted regarding how they influence one another over the course of development (Kwok et al., 2015).

A recent cross-sectional study, which included over 1500 minimally verbal autistic individuals between the ages of 5 – 18 years, found that those with limited expressive language also exhibited much lower receptive language skills as compared to nonautistic peers based on both direct assessment and parent report. Furthermore, this receptive language gap between autistic and nonautistic peers widened with age, indicating that as the language environments of neurotypical peers grow more complex with age, minimally verbal autistic individuals' receptive language may plateau and fall farther behind the pace of typical development (Chen et al., 2024). Nonetheless, more longitudinal research is needed to elucidate the ways in which expressive and receptive language are related and influence one another throughout development.

The vast majority of the research examining receptive and expressive language in autistic individuals has focused on discrepancies in receptive and expressive language profiles. For example, it has been proposed both by researchers and through clinical anecdotes that autistic

individuals have stronger expressive language skills as compared to receptive (Hudry et al., 2010; Volden et al., 2011). However, a meta-analysis conducted in 2015 examined 74 studies and found no evidence in support of this hypothesis (Kwok et al., 2015). Furthermore, these studies have primarily focused on standardized tests based on age norms which may show different patterns than more naturalistic measures of language use.

Measuring Expressive Language

Despite the importance of language in both day-to-day interactions and in predicting long-term outcomes, characterizing verbal ability in samples of autistic participants (as is commonly done with IQ or symptom severity) is not currently standard research practice (Mazurek et al., 2019). Furthermore, when language is assessed, methods of data collection vary widely. Some rely on standardized assessments, such as the Preschool Language Scales (PLS; Zimmerman et al., 2011) or the Clinical Evaluations of Language Fundamentals (CELF; Wiig et al., 2003). Standardized assessments are valuable because they allow for comparison to age-matched peers and can characterize different aspects of language, such as expressive and receptive. However, standardized language assessments may not be appropriate for all participants in a given study, particularly those with limited language skills who often score below the basal levels required for norm-referenced interpretation (Charman, 2004; Mazurek et al., 2019). Standardized assessments can also be demanding for participants and require specialized training to administer, making their use in some research trials less feasible. In addition, standardized assessments are not necessarily reflective of the language used in naturalistic settings. Rather, to some extent, standardized tests are intended to measure knowledge about language rather than how language is used in day-to-day contexts.

There has been a call for increased use of natural language samples in research because they most closely resemble language used in naturalistic settings and can be conducted with individuals of varying ages and language levels (Barokova & Tager-Flusberg, 2020). Scores across different aspects of language can be obtained, including phonetic, lexical, and pragmatic skills (Tager-Flusberg et al., 2009). Research has demonstrated that natural language samples correlate well with scores from standardized assessments (see Barakova & Tager-Flusberg, 2020 for review). However, they can be time consuming to administer (recommended length is approximately 30 minutes which can be taxing for younger or more cognitively impaired participants) and labor-intensive (requires recording, transcription, and coding of each sample).

Lastly, parent report questionnaires, such as the MacArthur-Bates Communication Development Inventories (MCDI; Fenson et al., 2006), are another widely used method for assessing language in autism research. These tools do not require any training or expertise to administer and likely reflect language used in naturalistic settings, as they are rated by caregivers who spend considerable amounts of time with the child. However, parent report questionnaires are subject to inherent biases based on parent perceptions or reporting styles (Guastella et al., 2015). Additionally, questionnaires vary based on developmental and communication profiles. Therefore, one questionnaire may not be appropriate for all participants in a given study.

As is discussed by Mazurek and colleagues (2019), the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2012) is one of the most widely used diagnostic assessments and is frequently implemented in research studies for diagnostic confirmation and characterization of symptom severity across samples. Though the focus of the assessment is not on language specifically, it provides a semi-structured context to elicit natural language use and scores language using a standardized coding system. Mazurek and colleagues (2019) argue that the

ADOS and, in particular, code A1 ("Overall Level of Non-Echoed Language" [OLL]) has utility in measuring expressive language in autistic individuals from toddlerhood through adulthood at varying developmental levels. A participant's language use throughout the ADOS is observed and subsequently scored by a trained assessor, making it less subject to bias than parent-report measures.

The authors point out that, due to its widespread implementation in autism research, the ADOS offers a unique opportunity to measure language in a consistent manner across studies using a measure that is already commonly included in assessment batteries, thereby lessening the variability in language data collection methods previously described and mitigating assessment burden for participants. Furthermore, the OLL code is advantageous in that it categorizes the complexity of natural language use based on linguistic milestones which are more clinically interpretable than scores from standardized language measures or other coded scores, such as mean length of utterance. These milestones cover the full spectrum of language use, ranging from no words to complex use of language with few grammatical markings. Thus, the authors created a single expressive language score by recoding the ADOS OLL item to allow for comparison across the five ADOS modules. In an effort to respond to calls for increased consistency within language research, as well as the ability to characterize language using clinically meaningful benchmarks that can be applied to language at any ability level, the current study will utilize an adapted version of Mazurek and colleague's (2019) ADOS OLL code to examine expressive language over time in a sample of autistic individuals.

Current Study

The current study leveraged data from a well-characterized longitudinal cohort of autistic individuals to analyze trajectories of expressive language throughout childhood and adolescence,

and the influence of receptive language (as opposed to aspects of nonverbal cognition, such as nonverbal problem solving or fine motor skills, which have been widely studied) on these trajectories, thus addressing gaps in the current literature. While previous research has characterized trajectories of language in the current sample (Pickles et al., 2014), the study used age equivalent scores from a standardized parent-report measure which combined expressive and receptive language. Conversely, the current study will focus exclusively on trajectories of expressive language using an observation-based assessment obtained from language used in a more naturalistic setting and which categorizes the structure of language using linguistic milestones.

Aim 1

The first aim set out to characterize the heterogeneous trajectories of expressive language development throughout childhood and adolescence. More specifically, calibrated scores from the ADOS OLL code (Mazurek et al., 2019) were used to estimate trajectory classes for expressive language skills from ages 2 to 18 years to distinguish groups that may emerge based on expressive language abilities over time. The trajectory classes were subsequently described in terms of cognitive and adaptive skills, ASD symptomatology, age of milestone attainment, social outcomes, and development of receptive language skills over time.

Aim 2

The second aim set out to examine how scores on a standardized receptive language measure in early childhood distinguish the expressive language trajectories determined in Aim 1.

Method

Participants

The current sample draws from a longitudinal cohort of 253 individuals who were originally recruited in the 1990s from three sources: (1) 192 children under the age of 3 years who were referred for an autism evaluation to two tertiary autism programs in North Carolina and Illinois; (2) 21 children under the age of 3 years identified through the aforementioned North Carolina and Illinois referral sources who were diagnosed with non-ASD developmental delays; and (3) 40 children diagnosed with either ASD or non-ASD developmental delays who were also diagnosed at early ages but who were identified and enrolled in the study at the approximate age of 9 years, were primarily from Michigan, and were subsequently evaluated at the same ages as the first two groups.

Because the current study sets out to examine language development in autistic individuals beginning in early childhood, analyses will include data from the 179 participants who were seen beginning at the age of 2 years and who were diagnosed with autism spectrum disorder (ASD) at some point throughout the study. The majority of participants were identified via parent report as being non-Hispanic White (66%) and Male (85%). Approximately 48% of parents and caregivers in this sample reported obtaining a four-year college degree or higher. Sample characteristics are included in Table 1. For information on the measures used to collect the demographic information, see “Measures” section below.

Table 1
Participant Characteristics

	M (SD)
Gender (females)	15%
Race (non-Caucasian)	34%
Maternal Education (4-year college degree)	48%
First ADOS CSS	7.61 (2.36)
Last ADOS CSS	5.59 (2.37)
First VIQ	34 (20)
Last VIQ	52 (44)
First NVIQ	66 (21)
Last NVIQ	57 (41)

VIQ: verbal intelligence quotient; NVIQ: non-verbal intelligence quotient; ADOS CSS: Autism Diagnostic Observation Schedule Calibrated Severity Score

Procedures

A battery of diagnostic, cognitive, and language measures were administered in-person at the approximate ages of 2, 3, 5 (only North Carolina participants at the year 5 cohort), 9, 18, 21, and 25 years. Clinicians, who included graduate students, post-doctoral research fellows, and licensed clinicians, were research reliable in all relevant measures and were blind to results from previous assessments. Following in-person assessments, clinical best-estimate diagnoses of autism, non-spectrum developmental delay, or typical development, as well as other conditions (e.g., ADHD, mood disorders, learning disabilities, other mental health issues) were provided based on standardized scores from gold-standard diagnostic instruments (such as the Autism Diagnostic Interview-Revised [ADI-R; Le Couteur et al., 1989; Rutter et al., 2003]) or the Autism Diagnostic Observation Schedule [ADOS]) and clinician judgment (Lord et al., 1994).

Informed consent was obtained from all participating families and, whenever possible, participants themselves. This research was IRB approved at various institutions across the duration of the study.

Measures

Expressive Language

The Autism Diagnostic Observation Schedule (ADOS) is a semi-structured observation designed to assess symptoms of autism. The ADOS has five modules (Toddler Module and Modules 1 – 4) from which the clinician chooses based on the age and language level of the participant. The ADOS item-level code "Overall Level of Non-Echoed Language" (OLL) is present in all modules and is used to assess the complexity of spontaneous speech used during the assessment. This item was recoded based on the conventions described in Mazurek et al. (2019) to allow for comparison across modules. The recoded values ranged from 0 ("No words or word approximations used meaningfully and/or spontaneously") to 7 ("Uses sentences in a largely correct fashion; must use some complex speech"). Descriptions of the recoded values can be found in Table 2. Scores from the calibrated ADOS OLL item were analyzed as the primary outcome measure of expressive language across time. Participants were administered the ADOS at approximately ages 2, 3, 5, 9, 18, 21 and 25 by research reliable administrators.

Table 2
Original A1 (OLL) Item Code by Module

New Expressive Language Code	Toddler Module	Module 1	Adapted Module 1	Adapted Module 2	Module 2	Module 3	Module 4	Description
1	4	4	5	5				No spontaneous words or word approximations
2	3	3	4	4	3			At least one word or word approximation, but fewer than 5 words during evaluation
3	2	2	3	3				Recognizable single words or word approximation only; must use at least 5 words during evaluation
4	1	1	2	2	2			Occasional phrases only, mostly single words
5	0	0	1	1	1	3	3	Regular use of utterances with two or more words
6			0	0	0	2	2	Non-echoed speech is mostly utterances of at least 3 words, but without complex language
7						1	1	Some relatively complex speech but with recurrent grammatical errors not associated with use of dialect
8						0	0	Uses sentences in a largely correct fashion (must use some complex speech)

Receptive Language

Receptive language was measured at ages 2 and 3 years using the Mullen Scales of Early Learning (MSEL; Mullen, 1995). The MSEL is a standardized, norm referenced measure of early childhood development. The MSEL is suitable for children from birth to 5 years, 8 months. Participants' receptive language scores from the MSEL at age 2 years (both raw and age equivalents were tested) was used to examine the influence of receptive language on expressive language trajectories. If a participant was not seen at age 2, the age 3 scores were used instead.

Additionally, mean receptive language age equivalents as measured by the Vineland Adaptive Behavior Scales Comprehensive Interview, First and Second Editions (VABS and VABS II; Sparrow et al., 2005; Sparrow & Cicchetti, 1985) was also plotted over time to describe the receptive language skills of the different trajectory groups between the ages of 2 to 25 years. The VABS was used instead of the MSEL to maintain a consistent measure of receptive language across all timepoints.

Autism Severity

The ADOS total score yields Calibrated Severity Scores (CSS) - standardized scores used to describe autism symptom severity which can be compared across individuals of varying ages and developmental levels. ADOS CSS scores range from 1 to 10, with scores of 1 denoting minimal-to-no evidence of autism symptoms and 10 denoting high levels of autism symptoms during the ADOS administration. ADOS CSS scores were used in the current analyses as a covariate.

Adaptive Behavior

The VABS and VABS II were used to assess adaptive skills in the domains of Communication, Daily Living Skills, and Socialization at approximately ages 2, 3, 5, 9, 14, 18,

21 and 25. The VABS Adaptive Behavior Composite (ABC) is a standardized composite score representing an overall summary of adaptive behavior across all domains. The VABS ABC scores were used to describe the adaptive skills of the trajectory groups over time.

Cognitive Skills

The MSEL was used to assess verbal and nonverbal IQ at age 2. Later cognitive assessments were chosen from a standard hierarchy which included the MSEL in addition to the Differential Ability Scales (DAS and DAS-II; Elliott, 1990, 2007), Wechsler Intelligence Scales for Children (WISC-III, WISC-IV, and WISC-V; Wechsler, 1991, 2003, 2024) and Wechsler Abbreviated Scales of Intelligence (WASI-II; Wechsler, 2011). When standard scores could not be obtained due to floor effects, ratio IQs were calculated. Verbal and nonverbal IQ scores at the first (2 year) and last (25 year) visits were used to describe the cognitive skills of the trajectory groups over time. If IQ scores were not obtained at the year 25 visit, scores from the year 18 visit were used instead.

Age of Milestone Attainment

The Autism Diagnostic Interview (ADI and ADI-R) was used to identify a participant's age of first words and age of first phrases. The ADI is a structured, comprehensive parent interview used to gather detailed developmental histories and information on social communication and repetitive behaviors. The ADI was collected at approximately ages 2, 3, 5, 9, 18, 21 and 25. The ADI collected at the timepoint closest to reported age of acquisition was used to minimize telescoping biases (Hus et al., 2011). Participants who reported not yet acquiring words by the age 5 ADI or phrases by the age 9 ADI and who were lost to further follow up after these ages were recorded as not having acquired the milestones. Values coded as never having attained the milestone or as missing were excluded from mean age calculations and categorical

variables were created indicating milestone attainment to characterize milestone attainment across trajectory groups.

Demographic Information

Demographic information was collected at each in-person visit. At the age 25 visit, information was collected regarding where the participants are currently living, friendships, and job attainment. This information was used to characterize the various expressive language trajectory groups in terms of social outcomes in adulthood.

Analytic Plan

Aim 1

Group-based trajectory modeling was used to identify subgroups of developmental trajectories of expressive language development over time. Analyses were conducted using the traj plugin in Stata 19 (Jones & Nagin, 2013). Models were estimated using full-information maximum likelihood; therefore, individuals with missing values can be retained in the models by estimating using all available information. The best fitting model and number of trajectory groups were determined using Bayesian Information Criteria (BIC).

Seven timepoints were used as independent variables to analyze the latent grouping of individuals in their expressive language trajectories. Unconditional 2, 3, 4, 5 and 6 class models were compared using BIC and the smallest group membership percentage (Table 3). After classes were established, higher order effects were tested to determine the best-fitting shape of each trajectory over time (i.e., linear, quadratic, cubic, or intercept only). Posterior probabilities for each individual's membership to each trajectory group were used to assign the most likely trajectory group for each participant. Average posterior probabilities of above 0.70 were used to determine adequate model fit (Nagin, 2005).

Table 3
Expressive Language Trajectory Model Selection

Model	BIC	Smallest Group %
2 Class Model	-1345.62	46.9
3 Class Model	-1264.49	30.0
4 Class Model	-1247.04	18.6
5 Class Model	**-1253.13**	**11.3**
6 Class Model	-1264.97	5.9

Note: Final model selected in bold

The ascertained trajectory groups were then described in terms of demographic characteristics as well as cognitive, adaptive, and linguistic profiles. Mean VABS receptive language age equivalent scores at the ages of 2, 3, 5, 9, 14, 18, 21, and 25 years were plotted across the trajectory groups to characterize differences in receptive language development over time. Due to attrition, missing receptive language data were addressed using Multiple Imputation with Chained Equations (MICE; Buuren & Groothuis-Oudshoorn, 2011). Predictive mean matching was used to impute receptive language scores at each timepoint. Twenty imputed datasets were generated, and estimates were pooled using Rubin's rules to account for uncertainty due to missing data. Participants were defined as lost to follow up if they were not seen at any of the adult visits (ages 18 or 21 or 25 years). Attrition was significantly associated with being racially diverse and caregiver education, such that Black participants ($p = .02$) and those whose caregivers did not obtain a college degree ($p < .001$) were more likely to be lost to follow up. Attrition was not associated with participant sex at birth, recruitment site, IQ, or expressive language trajectory group.

Aim 2

Multinomial logistic regression was conducted to examine the influence of early receptive language on expressive language trajectories. Specifically, raw scores from the MSEL receptive language domain at approximately age 2, in addition to chronological age at assessment and autism symptom severity at age 2 as measured by ADOS CSS scores, were used as independent variables and expressive language trajectory group as the dependent variable. Models predicted the log odds of trajectory group membership based on early receptive language; odds ratios and 95% confidence intervals are reported.

Results

Aim 1

A five-group model was determined to be the best fitting model. While the four-group model had a slightly more favorable BIC value as compared to the five-group model, the difference in BIC values was small and the five-group model allowed us to examine the subgroup (~11%) who started out with less language and eventually caught up to complex speech by age 5 years. Furthermore, in the five-group model, average posterior probabilities were above 0.70. The slopes of all five trajectories were cubic.

Characteristics of Expressive Language Groups

Stable No Words. As shown in Figure 1, the Stable No Words group was estimated to comprise 18.9% of the sample and remained non or minimally speaking from ages 2 to 25 years. This group is characterized by consistently high levels of impairment related to autism symptoms and very low verbal (below 20) and nonverbal (below 50) IQs and adaptive functioning across time (Table 4). According to parent report on the ADI-R, 41% of this group never demonstrated

any verbal communication, even as adults. Participants in this group would be considered to have profound autism (Sterrett et al., 2024).

Figure 2 depicts VABS receptive language scores across all trajectory groups between the ages of 2 and 25 years. The Stable No Words group is characterized by consistently low and slightly increasing receptive language skills over time. By age 25, this group had a receptive language age equivalent of approximately 4 years on the VABS meaning that they could generally comprehend basic "why," "what," and "how" questions, understand spatial and sequencing concepts, and follow some multi-step instructions.

Of the 22 participants in the Stable No Words group for whom adult data were gathered, 10 (45%) live at home with their parents/guardians, 10 (45%) live in a group home, 1 (5%) lives in their own home with support from care staff or guardians, and 1 (5%) lives in a staffed apartment with constant supervision. Two participants (9%) report (via parent report) having at least one friend while the remaining 91% report no friends. Data on employment were available for 20 participants. Seventeen (85%) were reported by parents as being unemployed, 2 (10%) worked a regular job with supports in place, and 1 (5%) worked in a volunteer position.

Stable Single Words. The Stable Single Words group was estimated to comprise 24.1% of the sample. As seen in Figure 1, participants in this group were using some single words by age 3 years which increased until approximately age 9 years and slowly declined between late childhood and adulthood. Similar to the Stable No Words group, the Stable Single Words group is also characterized by high levels of impairment related to autism symptoms with low verbal and nonverbal IQs and adaptive functioning across time, though slightly higher than the Stable No Words group. For example, nonverbal IQs at 2 were slightly higher in the Stable Single Words group than the Stable No Words group (low 60s vs high 40s) but, by adulthood,

nonverbal IQs were similarly very low (below 30). According to parent report, all participants in the Stable Single Words group demonstrated single words (first observed around 26 months, on average) and approximately 70% of the group had some simple phrases which were met, on average, before age 5 years. Receptive language age equivalent scores were low but increased slowly between the ages of 2 to 18. Between the ages of 18 to 21, a small decrease was observed. By age 25, the Stable Single Words group had a receptive language age equivalent of approximately 4 years – similarly to the Stable No Words group (see Figure 2).

Of the 26 participants in the Stable Single Words group for whom adult data were gathered, 16 (62%) live at home with their parents/guardians, 8 (31%) live in a group home, and 2 (8%) live in a residential facility. Two (8%) participants report (via parent report) having at least one friend while the remaining 92% report no friends. Employment data were available for 24 participants. Twenty-one (88%) were unemployed, 1 (4%) worked a regular job with supports in place, 1 (4%) worked at a special center which employs individuals with disabilities, and 1 (4%) was employed but was laid off during the COVID-19 pandemic.

Phrase Speech, Never Complex. The Phrase Speech, Never Complex group was estimated to comprise 20.6% of the sample. They entered the study at age 2 with slightly more expressive language than the two Low Language (i.e., Stable No Words and Stable Single Words) and Early Catch-Up groups; however, this group never attained complex speech even as adults. According to parent report, this group attained single words around the same time as the Single Words group. They differed from the Single Words group in that all participants attained phrase speech and at a younger age (approximately 4 years vs 5 years). The Phrase Speech, Never Complex group is characterized by high levels of impairment related to autism symptoms, low verbal IQs across time (in the 30s), but relatively higher nonverbal IQs that declined less

between age 2 and 25 years. Adaptive functioning in the Phrase Speech, Never Complex group is low and similar to the Stable No Words and Stable Single Words groups.

While receptive language age equivalent scores for the Phrase Speech, Never Complex group were still below age expectation, scores were higher for this group as compared to Stable No Words and Stable Single Words. As shown in Figure 2, the Phrase Speech group reached their highest receptive language scores around age 18 when age equivalent scores were approximately 8 years. A steep decline was noted between ages 18 and 21 years where receptive language skills then remained stable through 25 years.

Of the 24 participants in the Phrase Speech, Never Complex group for whom adult data were collected, 18 (75%) live at home with their parents/guardians, 5 (21%) live in a group home, and 1 (4%) lives independently in his/her own home without supports. Nine (38%) participants report (via parent report) having at least one friend while the remaining 62% report no friends. Employment data were available for 22 participants. Fourteen (64%) were unemployed, 3 (14%) worked a regular job without supports, 2 (9%) worked in a volunteer position, 1 (5%) worked at a regular job with supports in place, 1 (5%) worked in a special center which employs individuals with disabilities, and 1 (5%) was employed but was recently laid off (reason unknown).

Early Catch-Up. The Early Catch-Up group was estimated to comprise 11.3% of the sample. These participants entered the study with similar expressive language use as the two Low Language groups (i.e., Stable No Words and Single Words); however, they clearly diverged from the Low Language groups around age 4 years. By age 5 years, the Early Catch Up group had almost caught up to the Stable High-Language group. According to parent report, this group developed single words by age 2 years and phrase speech by approximately 3.5 years. The Early

Catch-Up group is still characterized by high degrees of impairment related to autism symptoms, but less so than the No Words, Single Words, and Phrase Speech groups. The Early Catch-Up group started out at age 2 years with similarly low VIQ (approximately 30, on average) to the Single Words and Phrase Speech groups but, by age 25, had increased considerably to 85, on average. The Early Catch-Up group had a higher NVIQ at 2 years as compared to the other groups (average of 73) which also increased to 85 by adulthood. Adaptive functioning was comparable to the lower language groups at age 2 but did not decline by adulthood as demonstrated by the lower language groups. The Early Catch-Up group is also characterized by a pattern of steep gains in receptive language between ages 2 to 9 years with continued growth through age 21 years. After age 21 years, receptive language begins to decline.

Of the 12 participants in the Early Catch-Up group for whom adult data were collected, 8 (67%) live at home with their parents/guardians, 2 (17%) live in their own home without supports, 1 (8%) lives in their own home with support from care staff or guardians, and 1 (8%) lives in a group home. Eight (67%) participants report (via parent report) having at least one friend while the remaining 33% report no friends. Employment data were available for 11 participants. One (9%) was unemployed, 8 (73%) were employed independently without supports, 1 (9%) worked in a regular job with support, and 1 (9%) worked in a special center which employs individuals with disabilities.

Stable High Language. The Stable High Language group was estimated to comprise 25.1% of the sample. This group reached the single words and phrase speech milestone at a younger age than all other groups, with parents reporting single words before 2 years and phrase speech before 3 years, on average. At age 2 years, the Stable High Language group showed the relatively lowest degrees of impairment related to autism symptoms, which continued to decrease

into adulthood. This group started out with the highest verbal and nonverbal IQs (53 and 83 on average, respectively) and both increased such that, by adulthood, their verbal and nonverbal IQs are comparable to typically developing age expectations. Their adaptive functioning, while starting out low at age 2, increased throughout adulthood to an average score of 81 by age 25 years. The Stable High Language group demonstrated consistent growth in receptive language over time and the highest receptive language age equivalents compared to the other groups.

Of the 34 participants in the Stable High Language for whom adult data were gathered, 21 (62%) are living independently in their own home without supports, 12 (35%) are living at home with parents/guardians, and 1 (3%) is living somewhere other than their own home, parents' home, group home, or residential facility. Twenty-three (68%) participants report (via parent report) at least one friend while the remaining 32% report no friends. Employment data were available for all 34 participants. Twenty-six (76%) participants were employed independently without supports, 1 (3%) worked a regular job with supports in place, 2 (6%) reported having work but recently being laid off and 5 (15%) were unemployed.

Table 4
Trajectory Group Characteristics

	Stable No Words *n = 37*	Single Words *n = 42*	Phrases Never Complex *n = 33*	Early Catch-Up *n = 18*	Stable High Language *n = 49*
Gender (females) *n (%)*	7 (19%)	4 (9.5%)	9 (27%)	2 (11%)	4 (8.2%)
Race (non-Caucasian) *n (%)*	15 (41%)	17 (40%)	9 (27%)	9 (50%)	11 (22%)
Age at First Assessment (years)	2.41 (0.5)	2.43 (0.4)	2.53 (0.3)	2.59 (0.4)	2.34 (0.5)
Age at Last Assessment (years)	25.8 (1.6)	26.2 (1.1)	25.8 (1.3)	26.1 (1.7)	25.9 (1.4)
First ADOS CSS *mean (sd)*	9.08 (1.14)	7.95 (2.23)	7.91 (2.13)	6.69 (2.65)	6.28 (2.48)
Last ADOS CSS *mean (sd)*	8.00 (0.0)	5.92 (0.64)	7.30 (2.21)	6.44 (2.13)	4.22 (2.50)
First VIQ *mean (sd)*	17 (6)	26 (10)	34 (14)	30 (11)	53 (23)
Last VIQ *mean (sd)*	5 (2)	20 (16)	37 (19)	85 (27)	102 (21)
First NVIQ *mean (sd)*	48 (17)	62 (18)	64 (16)	73 (22)	83 (15)
Last NVIQ *mean (sd)*	11 (5)	27 (16)	52 (30)	85 (25)	104 (21)
Age of First Words (months) – Parent Report *mean (sd)*	19 (10) 15 (41%) participants never met	26 (16) all participants met	29 (18) all participants met	23 (8) all participants met	22 (8) all participants met
Age of First Phrases (months) – Parent Report *mean (sd)*	NA no participants met	56 (22) 12 (29%) participants never met milestone	45 (20) all participants met	42 (7) all participants met	34 (7) all participants met
First VABS ABC *mean (sd)*	57 (6)	59 (6)	60 (6)	60 (4)	67 (9)

Last VABS ABC *mean (sd)*	20 (0)	23 (8)	35 (10)	64 (16)	81 (18)

VIQ: verbal intelligence quotient; NVIQ: non-verbal intelligence quotient; ADOS CSS: Autism Diagnostic Observation Schedule Calibrated Severity Score; VABS ABC: Vineland Adaptive Behavior Scales Adaptive Behavior Composite Standard Score

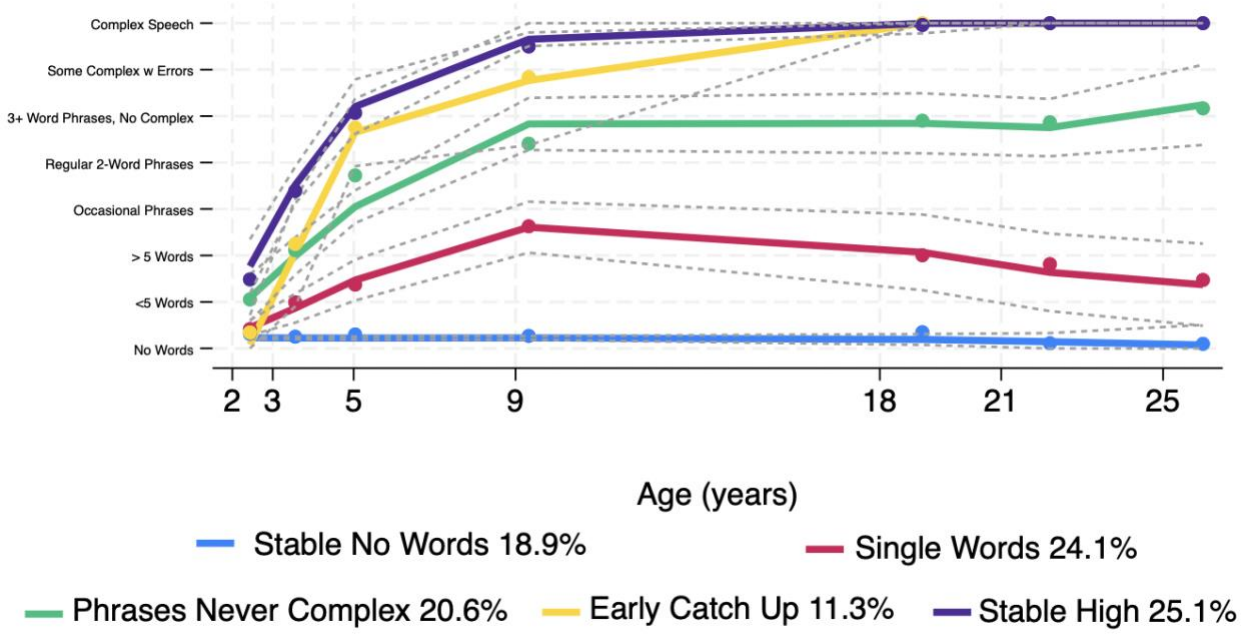


Figure 1. Expressive Language Trajectories from 2 to 25

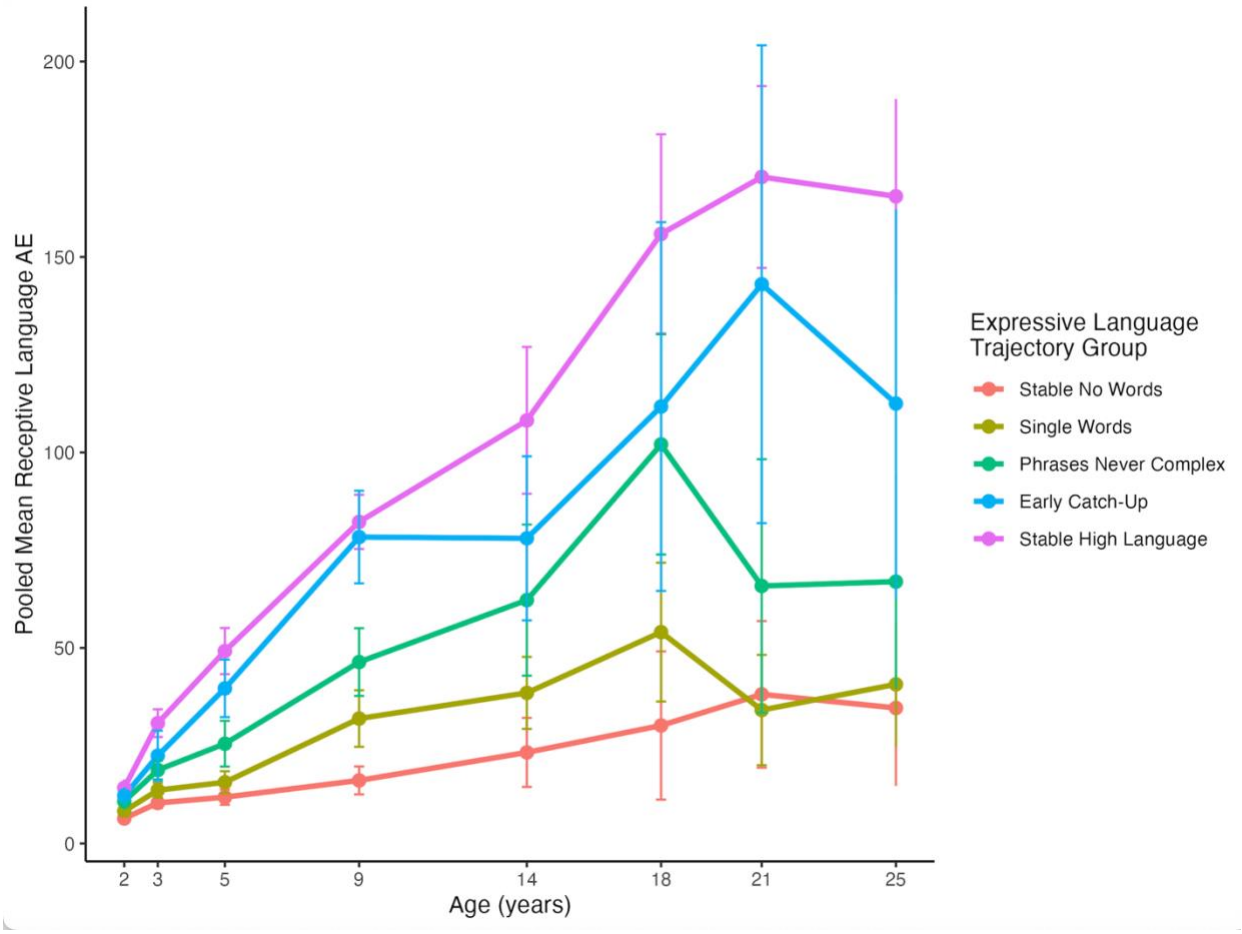


Figure 2. Mean Receptive Language Age Equivalent Scores Plotted Across Trajectory Groups

Aim 2

Multinomial logistic regression was used to examine whether receptive language raw scores at the first data collection timepoint (approximately age 2 years) distinguished expressive language trajectory group membership while controlling for chronological age at assessment and autism symptom severity at the first data collection timepoint. Using the Stable High Language trajectory as the reference group, higher receptive language raw scores were associated with a significantly lower likelihood of belonging to all four alternative expressive language trajectories, even after controlling for age and symptom severity (*OR*s = 0.60 – 0.79, *p*s < .01).

Chronological age associated with a raw score independently predicted trajectory group membership, such that older participants at the same raw score were more likely to belong in lower expressive language trajectories (*OR*s = 1.15 – 1.24, *p*s < .01). Autism symptom severity did not significantly predict trajectory group membership after accounting for receptive language and chronological age at receptive language assessment (*p*s = .11 - .72). Table 5 provides the odds ratios (ORs) and 95% confidence intervals (CIs) for being in each trajectory group compared to the Stable-High Language group.

Table 5
Multinomial Logistic Regression Predicting Expressive Language Trajectory Membership

Predictor	Stable No Words vs Stable-High	Stable Single Words vs Stable-High	Phrase Speech – Never Complex vs Stable-High	Early Catch-Up vs Stable-High
Early Receptive Language (raw score)	0.60 (0.48 – 0.73) ***	0.73 (0.64 – 0.84) ***	0.87 (0.78 – 0.97) **	0.84 (0.74 – 0.96) **
Age at Assessment (months)	1.15 (1.03 – 1.29) **	1.16 (1.05 – 1.28) **	1.19 (1.07 – 1.32) **	1.24 (1.09 – 1.41) ***
Early Autism Symptom Severity (ADOS CSS)	1.38 (0.93 – 2.05)	0.95 (0.74 – 1.24)	1.16 (0.88 – 1.51)	0.91 (0.67 – 1.23)

* $p < .05$, ** $p < .01$, *** $p < .001$

Due to lack of agreement in the field regarding the use of raw scores vs age equivalent scores in assessment with developmentally delayed children, a sensitivity analysis was conducted in which receptive language measured using age-equivalent scores was included in the model. Results yielded a largely consistent pattern of results, though differentiation of trajectory groups

was reduced. Receptive language age equivalent scores predicted two of the four expressive language trajectories after controlling for autism symptom severity. Furthermore, autism symptom severity was weakly associated with membership in the Stable No Words group, potentially due to measurement confounding between developmental level and symptom severity. These results suggest that accounting for age-related variance in raw scores enhanced trajectory membership distinction. Table 6 provides the odds ratios (ORs) and 95% confidence intervals (CIs) for being in each trajectory group compared to the Stable-High Language group using age equivalent scores instead of raw scores.

Table 6
Multinomial logistic regression predicting expressive language trajectory membership

Predictor	Stable No Words vs Stable-High	Stable Single Words vs Stable-High	Phrase Speech – Never Complex vs Stable-High	Early Catch-Up vs Stable-High
Early Receptive Language (age equivalent scores)	0.65 (0.53 – 0.79) ***	0.80 (0.71 – 0.90) ***	0.95 (0.88 – 1.03)	0.97 (0.89 – 1.05)
Early Autism Symptom Severity (ADOS CSS)	1.47 (1.00 – 2.16) *	1.02 (0.71 – 0.90)	1.23 (0.96 – 1.56)	1.00 (0.77 – 1.31)

* $p < .05$, ** $p < .01$, *** $p < .001$

Discussion

There is considerable heterogeneity in the expressive language development of autistic individuals across the lifespan. In the current study, five distinct trajectory classes were identified based on expressive language skills between the ages of 2 to 25 years. Two low-language groups emerged comprising over 40% of the sample. One such group was characterized

by little to no verbal speech across the lifespan while the second group was observed to communicate using single words.

Neither low language group transitioned to flexible, phrase speech by adulthood. Around the age of 2 years, both low language groups had verbal IQs below 30 and nonverbal IQs below 70, with the lowest language group below 50. Both groups are characterized by decreasing verbal and nonverbal IQs over time. While this does not necessarily indicate that these groups are losing skills, the participants in these groups became increasingly disparate from same aged peers over time in terms of cognition and language. By age 25 years, verbal IQs were below 20 and nonverbal IQs were below 30. Both groups also demonstrated consistently low adaptive functioning and high autism symptom severity from early childhood into adulthood. By adulthood, none of the individuals in the two low language groups lived independently and most were reported as having no friends and no employment of any kind.

In contrast, the Stable High Language group had the most advanced adaptive and cognitive skills across all timepoints. Verbal and nonverbal IQs were approximately average by age 25 years. They also had the lowest ADOS CSS scores which decreased over time, meaning that symptoms of autism became less impairing in adulthood. Interestingly, although scores were relatively high compared to all other trajectory groups, adaptive skills of the Stable High Language group in adulthood were more than one full standard deviation below age expectations. This finding corresponds with literature documenting adaptive skill deficits in cognitively able autistic adults (Clarke et al., 2021; Yon-Hernández et al., 2023) and corroborates the need for continued intervention throughout adulthood for autistic adults, even those with low support needs, to bolster daily living skills needed for independence (Auld et al., 2022; Bal et al., 2015; Smith et al., 2012; Teh et al., 2024).

Even among the participants with the most advanced language, cognitive, and adaptive skills, approximately 20% of the Stable High Language group did not have employment and 30% were reported to not have a friend and to be living at home with their parents at age 25 years. Rates of autistic adults living at home with caregivers vary widely based on sample characteristics and geographic location. Data from the National Longitudinal Transition Study-2 (NLTS2) collected in 2009 demonstrated that less than half (45%) of autistic young adults with the highest level of conversation skills in the US ever lived independently (Roux et al., 2015). Rates are much lower for autistic adults with higher support needs (Forbes et al., 2023). Yet, many autistic adults consider independent living crucial for overall well-being.

In a recent qualitative study conducted with autistic adults with high verbal language, participants spoke of the importance of independent living with one participant reporting that, "on a scale of one to ten, it's about a fifteen." Another participant stated that living independently was, "the most important thing in my life" (Al Ansari et al., 2024). Nonetheless, all participants in the study noted that there were unexpected challenges to independent living including how to find an appropriate place to live, difficulty living with and communicating with roommates, independent transportation, and financial challenges. Similar challenges have been documented in independent samples (Ghanouni et al., 2021). More research and intervention is needed to understand the barriers and support the skills required for autistic adults with lower support needs and high verbal language to live independently and obtain gainful employment.

A further group of approximately 20% of the current sample transitioned to phrase speech by the age of 5 years but never developed complex, multiclausal sentences. While the Phrase Speech, Never Complex group demonstrated similarly low IQs at study entry as the two low language groups, this group did not demonstrate the same large decreases in nonverbal IQ

over time. In adulthood, verbal IQ remained in the 30s and nonverbal IQ in the 50s. Nonetheless, adaptive functioning for this group remained as low as that of the two low language groups. The majority of this group was living at home with a caregiver or guardian and approximately two-thirds were reported as not having a friend in adulthood. Approximately one-third had employment of some kind in adulthood which included volunteer work or working at a specialized center.

Approximately 11% of the sample was characterized by steep expressive language gains between the ages of 2 to 5 years. By age 5 years, this group had almost caught up to age expectations in expressive language. Individuals in this group demonstrated increasing IQs over time and less impairment related to symptoms of autism as compared to the No Words, Single Words, and Phrase Speech groups. Most were living at home with their parents at age 25 years, though some lived independently without supports. Two-thirds were reported as having a friend and almost three quarters were independently employed. Importantly, this Early Catch-Up group consistently demonstrated adaptive skills more than two standard deviations below the mean. As adults, although these participants may demonstrate expressive language similar to the Stable High Language group, they likely benefit from more intensive adaptive skill supports to bolster the skills needed to live independently and obtain gainful employment.

Findings from the current study indicate that at least some spoken language can be acquired by the majority of autistic individuals. However, a substantial minority will not develop spoken language in ways that allow them to effectively communicate with others. The estimated proportion and profile of cognitive and adaptive skills in the current sample are consistent with recent research documenting persistence of minimal to no spoken language use even after intensive early interventions (Vivanti et al., 2025). However, rates in the current study may be

slightly higher due to cohort differences, as this sample was identified over 30 years ago and may represent individuals with greater support needs than those typically seen in clinical samples today. Previous research has also documented greater language growth in participants with higher baseline cognitive skills and lower autism symptom severity (Chetcuti et al., 2025; Frazier et al., 2021).

The results of the trajectory analyses make clear the heterogeneity, not only of expressive language development in autistic individuals, but also of the broader cognitive, adaptive, and social outcomes that accompany these trajectories. Distinct developmental profiles are associated with differing patterns of strengths and challenges in autistic individuals. It is important to recognize these differences in order to appropriately tailor supports and interventions based on individual needs. For example, individuals in the lower language trajectory groups – who also demonstrate markedly lower cognitive and adaptive functioning – are likely to require more intensive interventions focused on the development of intentional communication and create ways for these individuals to make sense of their environment. The goals of intervention are likely to remain relatively consistent across the lifespan. In contrast, individuals in the higher language trajectory groups may benefit from more targeted social skills interventions aimed at the nuances of social interactions, making and maintaining relationships, and adaptive skill development. As these individuals get older, intervention targets may shift towards vocational and other skills aimed at supporting independent living. Moreover, the frequency, intensity, and scope of these various interventions should vary based on individual profiles.

Results from the trajectory analysis also revealed that the complexity of expressive language, as measured by linguistic milestones observed on the ADOS, continued to develop for most groups until age 9 years. After age 9 years, language growth plateaued for most groups.

These results are largely consistent with prior research suggesting that language development becomes increasingly linear in later childhood, with the likelihood of rapid progression waning over time. Findings from the current paper suggest a later age of plateau compared to findings reported by Pickles and colleagues (2014). In their trajectory analyses conducted on an overlapping sample, language growth became linear after approximately 5 years of age, whereas the present results suggest continued development for most groups (other than the Stable No Words) through age 9 years. It is possible that the difference in finding is due to differences in measurement. The current study used natural language samples coded by a trained clinician on the ADOS, a 45-minute observational assessment, and measured as linguistic milestones. Pickles et al. (2014), on the other hand, combined expressive and receptive language age equivalents as measured by parent-report on the VABS.

While promising to see that language may still be developing up to age 9 years, it is also noteworthy that most groups remained in the same linguistic milestone (i.e., single words, phrases, complex speech) after 5 years of age. Only the Early Catch-Up group transitioned to complex speech after the age of 5 years. While specific ages when language growth is most likely to slow are not yet identified, it is clear that early childhood is considered a "critical period" in which the acquisition of language comes more rapidly and with more ease as compared to later childhood (Pickett et al., 2009). During this time, there is greater possibility of dramatic shifts in trajectories, allowing for some initially delayed children to "catch-up" to age-appropriate norms (Lord et al., 2018).

It is also important to note that approximately 40% of the current sample exhibited "some" speech (single words or phrases) as adults, placing them between the linguistic endpoints of nonverbal and complex speech. This group remains markedly understudied - little is known

about the factors that contribute to the development of some spoken language without progression to more complex expressive abilities. More research in this area is warranted to better understand the autistic individuals who do not achieve "functional speech" by age 5 years but demonstrate more expressive language than are typically observed in minimally verbal research samples.

Receptive language skills demonstrated a consistent gradient across the five trajectory groups, increasing stepwise from the No Words group to the Single Words, then Phrase Speech and Early Catch Up, and reaching the highest levels in the Stable High Language group. At age 2 years, receptive language skills across all groups were similar. The expressive language groups began to diverge in receptive language skills more clearly around age 5 years. Interestingly, declines in receptive language were observed for the Single No Words and Phrase Speech groups at age 18 years and for the Early Catch-Up group at age 21 years. It is possible that these declines coincide with the transition out of schooling – a period during which day-to-day environments may place fewer demands on receptive language potentially contributing to reduced opportunities for continued growth. Similar patterns have been documented in other areas of functioning, such as daily living skills (Clarke et al., 2021).

Results from the multinomial logistic regression indicate that early receptive language ability predicts the development of expressive language above and beyond age-related differences and autism symptom severity. These findings support the notion of receptive language as an early-emerging, prognostically meaningful indicator of expressive language development. Receptive language deficits limit a child's ability to access the rich learning opportunities embedded in everyday interactions (Grow & LeBlanc, 2013). Over time, these missed opportunities may constrain broader developmental progress. Thus, interventions aimed

at increasing expressive language in autistic individuals should also target and build on receptive language abilities, as strengthening comprehension can maximize opportunities for learning and support gains in expressive communication.

Parents and caregivers provide an invaluable source of language input and opportunities to build both receptive and expressive language in autistic children. Longitudinal research has demonstrated that parental linguistic input has a positive influence on subsequent language use in autistic populations (Choi et al., 2020; Smith et al., 2023). Interventions aimed at bolstering expressive language may incorporate psychoeducation and caregiver strategies aimed at improving language input and responsiveness (Clark-Whitney et al., 2022; Edmunds et al., 2019; Flippin & Watson, 2015; Romeo et al., 2022).

Finally, this study was strengthened by the method of measurement used to characterize the complexity of expressive language of the participants in the sample. The current study measured expressive language by eliciting natural language within a semi-structured observational assessment lasting approximately 45 minutes and was coded by a trained assessor. This allowed for a cohesive method of measurement across participants of widespread developmental levels and ages. This method of measurement was also less susceptible to bias as compared to parent report measures. Furthermore, this is the first study to my knowledge which characterized language level across development using easily interpretable linguistic milestones allowing for more straightforward comparison across research samples.

Limitations

Several limitations of the current study warrant consideration. As noted previously, this sample is unique in that families sought initial autism evaluations during the early 1990s – a period when conceptualizations and diagnostic practices for autism differed substantially from

those today. Consequently, participants in the current study may be phenotypically different than children identified in more recent cohorts (Lord, Charman, Havdahl, Carbone, Anagnostou, Boyd, Carr, de Vries, et al., 2022). Furthermore, although missing data were addressed using multiple imputation, attrition over time led to reduced number of participants and more missing data in the adult cohorts, particularly participants who are Black and whose parents are not college educated. As a result, findings may underrepresent individuals from more diverse and socioeconomically disadvantaged backgrounds, potentially biasing later developmental outcomes.

The method of receptive language measurement over time was also a limitation. Receptive language was measured using a single measure, the VABS parent interview, rather than a multi-method or clinician administered assessment. Although this assessment is scored by a trained assessor, this approach may be influenced by informant bias and may not fully capture the complexity of receptive language abilities across contexts and developmental stages. The VABS receptive language domain is also constrained by a ceiling effect, limiting its ability to capture variability in receptive language skills and potentially obscuring developmental differences at more advanced levels.

Future Directions

More research is needed to better understand the various expressive language trajectories seen in autistic individuals and what factors predict inclusion into each. It has been well documented that earlier age at language acquisition is predictive of better outcomes. As such, understanding factors that predict language development and, specifically, predict the acquisition of flexible, generative speech are crucial for developing effective interventions and supporting skills necessary for independence.

Future research should also aim to better understand the developmental trajectories and outcomes of those whose language acquisition gets "stuck" - those who develop some spoken language but who do not progress to more complex expressive language. Finally, researchers must consider the ways that language is being measured and reported. Future research should incorporate the use of empirically driven linguistic milestones to support interpretability and comparisons across samples (Byrne et al., 2024).

Conclusion

The longitudinal and prospective nature of this study provides insight into how factors such as receptive language are related to the development of expressive language over time. A deeper understanding of the connection between receptive and expressive language trajectories and outcomes in autistic individuals can be leveraged by clinicians and researchers to develop, improve and adapt targeted language interventions based on individual communication profiles. This study was uniquely equipped to address these aims as it utilized a comprehensively characterized longitudinal sample which included fine-grained language data and natural language samples to allow for in-depth analysis of language trajectories from toddlerhood into adulthood for autistic individuals.

Furthermore, the use of a valid, well-established observational measure commonly used in autism research, the ADOS, to characterize the complexity of expressive language use in a semi-structured and naturalistic way allowed for better comparison of fine-grained language abilities across samples, thereby fostering increased consistency within autism research (Mazurek et al., 2019). Identifying aspects and targets of intervention that may be uniquely beneficial, such as receptive language, and for whom they benefit most, allows for tailored interventions based on individual profiles, thus increasing the likelihood for functional,

generative language for autistic individuals that allow for participation in day-to-day activities across a range of contexts. As such, the use of communicative, generative speech may become possible for a greater number of autistic individuals and, therefore, improve outcomes across other related domains.

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