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Heterogeneity and plasticity in the development of language: a 17-year follow-up of children referred early for possible autism

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Background: Delayed, abnormal language is a common feature of autism and language therapy often a significant component of recommended treatment. However, as with other disorders with a language component, we know surprisingly little about the language trajectories and how varied these might be across different children. Thus, we know little about how and when language problems might resolve, whether there are periods of relative stability or lack of change and what periods might offer more favourable circumstances for intervention. **Methods:** Expressive and receptive language was measured on six occasions between age 2 and 19 on a cohort of 192 children initially referred for autism**.** Latent class growth models were fitted to characterize the patterns of heterogeneous development. **Results:** Latent class growth analysis identified seven classes. Between age 6 and 19, all classes tracked in parallel. Between ages 2 and 6, development was more heterogeneous with considerable variation in relative progress. In all groups, receptive and expressive language developed very largely in tandem**. Conclusions:** The results confirmed previous analysis of children with specific language impairment where progress beyond age 6 was remarkably uniform. Greater variation was evident before this age with some groups making clearly better or worse progress compared to others. While this developmental heterogeneity may simply be a reflection of variation in preexisting and unchanging biological disposition, it may also reflect, at least in part, greater sensitivity in the early years to environments that are more or less supportive of language development. These findings contribute to the case for the importance of early intervention.
Keywords: Early intervention, heterogeneity, language impairment, plasticity.

Introduction

There has long been an interest in the language of children with autism, for example on the discrepancy between expressive and receptive performance (Hudry et al., 2010) and characterizing idiosyncratic use and understanding. It is also clear that good early language development is associated with better outcomes for children with autism (Mawhood, Howlin, & Rutter, 2000). However, we know much less about the development of language from inception to adulthood. Indeed, the reports from cohort studies of language development among children with disorders of all kinds remain relatively scarce (Bishop & Edmundson, 1987; Johnson et al. (1999); Law, Tomblin, & Zhang, 2008). Understanding when and what aspects of language are more subject to developmental change has become of importance for the treatment of autism, as a growing number of therapies for autism are based on or include components of speech and communication therapy (e.g. Green et al., 2010).

It is commonly thought that language development might be a more variable aspect of development and a more malleable ability than IQ. However, Conti-Ramsden, St. Clair, Pickles, and Durkin (2012) applied a modified version of the popular discrete class trajectory modelling approach to a sample of children identified at age 6 with specific language impairment (SLI), adapted for dealing with the problem of changes in assessment instrument from age to age. Using formal language tests (not just vocabulary), they reported expressive and receptive language development that progressed from age 6 to age 16 in a remarkably stable fashion. Having removed occasion specific fluctuation, the classes maintained their relative level with no indication of there being heterogeneity with respect to delay or catch-up. Of the seven classes identified, two small classes were unusual in having higher expressive than receptive language standard scores, a difference that was maintained with age. By contrast, application of similar methods to measures of performance IQ yielded evidence of comparatively greater, though still modest, variability, with some classes showing relative gains and losses compared to others.

This unexpected relative stability of language ability beyond age 6 inevitably focuses attention on the preschool years as a window in the natural history of language development during which more change might be occurring. If preschool natural history was found to be more variable, this could be interpreted as implying greater potential for intervention to have an effect, with clear clinical implications.

The processes underlying language development among children with ASD cannot be assumed

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identical to those for children with SLI (Luyster, Seery, Talbot, & Tager-Flusberg, 2011). Persistent SLI appears to be neurologically distinctive from ASD (Whitehouse & Bishop, 2008) and reports of language loss are rare in SLI in the absence of ASD (Pickles et al., 2009; Tager-Flusberg, Paul, & Lord, 2005). Thus, the relative stability of language trajectories might also differ.

The aims of this article were: (a) to examine the evidence for qualitative heterogeneity in the pattern of language development in children with ASD; (b) to assess the extent to which such heterogeneity in patterns occurs primarily early in development, prior to the start of formal schooling, and whether development beyond that is more a continuation of relative abilities achieved prior to schooling; (c) to assess whether we see trajectories that show distinct and changing patterns in the relationship between expressive and receptive language or is this relationship simply one of a stable difference and (d) to describe how variables characterizing the children, their directly assessed cognitive abilities, more general functioning, autism symptom scores and their early treatment were associated with different language development trajectories.

Sample

Participants

Described in more detail elsewhere (Anderson, Liang, & Lord, 2014; Lord et al., 2006), eligible participants were consecutive referrals younger than 37 months of age from agencies across North Carolina and metropolitan Chicago serving very young children with delays. Participants consisted of 192 children (162 males, 30 females) referred for evaluation for possible autism. Exclusion criteria included moderate to severe sensory impairments, cerebral palsy or poorly controlled seizures. None were identified with Fragile-X, but in the years that followed, a further four received a diagnosis of mild cerebral palsy. For this description of a naturalistic cohort, these were not excluded. By age 19, 106 youths from the original sample and their families continued to participate sufficiently to be included in this study. Written informed consent was obtained prior to each assessment from parents and, where appropriate, their child. The research was approved by the appropriate Internal Review Boards.

Measures

The full battery of diagnostic and psychometric instruments was administered at each assessment, free of charge in most cases by research teams unfamiliar with a participant's previous diagnosis and test scores. Verbal feedback and a written report were provided to families.

Diagnostic instruments. A diagnostic evaluation using both the Autism Diagnostic Instrument-Revised (Lord, Rutter, & Le Couteur, 1994) and versions of the Autism Diagnostic Observation Schedule (ADOS; DiLavore, Lord, & Rutter, 1995; Lord et al., 2000) was undertaken. An overall best estimate diagnosis of autism, PDD-NOS or other nonspectrum disability was jointly determined by two trained staff members, including Ph.D.-level research associates, child psychiatrists or clinical psychologists. For a more detailed description of the procedures see Lord et al. (2006).

Psychometric instruments. At each time point, children were assessed using the Vineland Adaptive Behavior Scales (VABS: Sparrow, Balla, & Cicchetti, 1984; Sparrow, Cicchetti, & Balla, 2005), a standardized, semistructured, parent interview designed to assess adaptive functioning. Age equivalents for expressive and receptive language from the communication domain were used in our analyses because of floor effects with the standard scores for many of the children with cognitive delays and for simplicity of interpretation. Simple correlations of the language age equivalents from the VABS and Mullen Scales of Early Learning (MSEL: Mullen, 1995) for 519 assessments made between the ages of 2 and 9 were 0.85 for expressive and 0.83 for receptive domains. VABS Daily Living standard scores were used to describe level of functioning.

IQ scores at 2 years of age were obtained from the MSEL. At age 19, cognitive test selection followed a standard hierarchy designed for use when the youths could not achieve a basal score or achieved ceiling scores (see Lord et al., 2006). Ratio IQs were calculated when raw scores fell outside the ranges for deviation scores.

Treatment measures. Parents completed diaries and were interviewed about all educational and specific treatments received by their child. Two raters established reliability and coded the data. We report the total number of therapy hours received through age 5 from speech-language pathologists and all individual therapists. The numbers of families who participated in Applied Behavior Analysis (ABA) and a mentored, parent implemented (MPI) therapy modelled after the North Carolina TEACCH program (Parent Treatment and Education of Autistic and Communication Handicapped Children) are also reported.

Statistical analysis

We used multivariate latent growth curve modelling to estimate models for the joint development of expressive and receptive language age-equivalent scores from the waves of data collection at 2, 3, 5, 9, 14 and 19 years of age. The model allowed intercept,

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linear and quadratic trends with age in the separate means for expressive and receptive language. Variation around these means was decomposed into measurement error and latent growth components. Scores of zero were possible and were considered as values on the floor of the test. These were treated as censored observations from a conditional normal distribution. We allowed for differences in error variances for expressive and receptive language that could change with age (i.e. heteroscedasticity as a function of measure, age and their interaction). The latent growth component was treated as a latent class mixture, first over the intercept, linear and quadratic slope dimensions common to both expressive–receptive language. These models assumed that while language development classes could take on quite different trajectories, the classes shared a common and fixed pattern of discrepancy in expressive and receptive language. Subsequent models allowed the classes to have progressively more different patterns of expressive–receptive discrepancy, first in mean level, then in linear and quadratic trend.

The models can be described algebraically for measure j (expressive or receptive), for participant i ($i = 1,\ldots,N$) at measurement occasion t as in Equation (1) below

$$y*_{ijt} = \sum_k \pi_k \left(\alpha_{jk} + \beta_{jk}\text{age}_{it} + \gamma_{jk}\text{age}^2_{it}\right) + \varepsilon_{ijt} \text{ for } k = 1,\cdots,K \quad (1)$$

and where we observe $Y_{ijt} = y*_{ijt}$ if $y*_{ijt} > c$ and $Y_{ijt} = 0$ if $y*_{ijt} \leq c$, and π_k is the prevalence of class k among K classes.

For reasons of clarity of interpretation, we chose to model age equivalence. We did not think it likely that an assumption of a constant measurement error variance with age was plausible for measures on the age-equivalent scale. We therefore allowed for variation in measurement error (heteroscadasticity) across measures (receptive or expressive) and with age such that log(sqrt(var(ε_{jt}))) = $\phi_j + \xi_j$ age$_{it}$ where ϕ_j and ξ_j are parameters to be estimated.

For the best fitting model, we also examined the relative performance of a restricted model shown below in which the expressive–receptive discrepancy was accounted for by the parameters (δ, λ, η), allowing the discrepancy to vary with age but assumed common to all classes as in Equation (2) below

$$y*_{ijt} = \sum_k \pi_k \left(\alpha_k(1+\partial_j) + \beta_k(1+\lambda_j)\text{age}_{it} + \gamma_k(1+\eta_j)\text{age}^2_{it}\right) + \varepsilon_{ijt} \text{ for } k = 1,\ldots,K. \quad (2)$$

This is equivalent to a discrete latent trajectory model for an underlying language factor in which the linear and quadratic components of change for receptive language are a simple scaled version of those for expressive language.

We compared the performance of models with increasing numbers of classes using the Bayesian Information Criterion (BIC; Pickles & Croudace, 2010). Models were estimated by full maximum-likelihood using all available data in Stata using the procedure gllamm (Rabe-Hesketh, Skrondal, & Pickles, 2004) (www.gllamm.org) providing valid inference under an assumption that the missing data mechanism is ignorable. We calculated posterior probabilities of class membership for each participant, and assigned individuals to their class with the highest assignment probability, so-called MAP assignment. We expected the sample to be dispersed across quite a number of trajectory classes of qualitatively different forms and sizes. This made it difficult to construct a priori hypotheses about class predictors that would have had respectable power. We therefore use the data on children's other characteristics descriptively.

Results

Model selection

The first column of Table 1 gives descriptive statistics for the sample of 192 participants with reports of expressive or receptive language obtained at approximately 2, 3, 5, 9, 14 and 19 years of age. Of these 1690 reports, 49 expressive and two receptive measurements were at the floor of the test. Table 1 gives the correlations among these measures. This shows that the correlation with measurements at age 2 declines progressively with age but remains substantial even by age 19, and that the correlations from age 3 and 5 are substantially higher than at 2. Such a pattern could be the result of higher levels of measurement error at age 2 or could be due to there being greater real change earlier followed by relative stability later on.

Table 2 gives the measures of relative fit of a range of models with the number of classes increasing from top to bottom and the ways in which the classes can differ one from another varying from left to right. Models of Type 1 assume that classes differ one from another in the same way for both expressive and receptive language. Types 2 to 4 allow the expressive–receptive difference to differ by class, first as a time constant difference (Type 2) and then as a difference that may change linearly with age (Type 3) or curvilinearly (Type 4). Type 5 includes restricted (factor) models in which age and class differences in expressive language are scaled versions of those in receptive language (see equation 2 above). The log-likelihood criterion shows the inevitable improvement in fit with increasing numbers of classes. However, the minimum BIC criterion, which penalizes complex models with more parameters to favour simpler models, suggests that seven classes should be preferred (in bold among Type 1). The table also shows that allowing the discrepancy between receptive and expressive language to vary over time by

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Table 1 Sample correlation matrix for Vineland expressive and receptive language measures at ages 2, 3, 5, 9, 14 and 19 years of age (all significant)

	Exp 2	Exp 3	Exp 5	Exp 9	Exp 14	Exp 19	Rec 2	Rec 3	Rec 5	Rec 9	Rec 14
Exp 3	.59										
Exp 5	.57	.68									
Exp 9	.58	.70	.73								
Exp 14	.54	.71	.87	.79							
Exp 19	.52	.72	.72	.81	.84						
Rec 2	.79										
Rec 3	.50	.88					.55				
Rec 5	.59	.76	.87				.58	.67			
Rec 9	.51	.71	.73	.84			.53	.69	.81		
Rec 14	.34	.58	.68	.62	.80		.37	.49	.72	.63	
Rec 19	.34	.60	.69	.68	.70	.70	.42	.60	.67	.63	.64

Table 2 Model fit comparisons using log-likelihood and Bayesian Information Criterion (BIC) with selected model in bold

		Deviations of classes from mean expressive/receptive trend: I, intercept; L, linear slope; Q, quadratic slope				Factor model
Classes		Type 1 I, L and Q common to expressive and receptive	Type 2 Expressive and receptive specific I, common L and Q	Type 3 Expressive and receptive specific I and L, common Q	Type 4 Expressive and receptive specific I, L and Q	Type 5 Expressive and receptive specific I, L and Q
6	Log-L	6747.18	6745.54	6715.38	6705.83	6727.05
	BIC	13654.19	13667.57	13643.87	13651.4	13629.92
	Parameters	30	35	40	45	33
7	Log-L	**6715.75**	6712.96	**6682.47**	6671.35	**6695.31**
	BIC	**13612.65**	13639.04	**13610.03**	13619.75	**13587.76**
	Parameters	**34**	40	**46**	52	**37**
8	Log-L	6711.73	6706.67	6672.74	6661.83	6687.63
	BIC	13625.91	13653.10	13622.53	13638.01	13593.70
	Parameters	38	45	52	59	41

allowing measure-specific intercept and linear slope (Type 3) improved the fit according to the BIC criterion, and that again the 7-class model fitted best (bold among Type 3). Using this model, individuals were assigned to their most likely class, generally with considerable confidence (mean posterior class-probability 89%, Table 3).

Trajectory class descriptions

Figure 1 shows the smoothed trajectories for the mean expressive and receptive age equivalents of the individuals assigned to each class. The age span of the lines is determined by the ages of available assessments for the individual participants assigned to each class, with thicker lines for larger classes. Because of the age-equivalent scale, we used a log-scale for both age and the Vineland age-equivalent score. This enables important discrepancies to be visible across the whole period of observation. Typically, developing children would be expected to fall on the normative line connecting (1,1) and (19,19), a pattern approached only by the small 'Near Typical' group. While all classes improve, before age 7, class improvement is quite heterogeneous, with some 'slow-starting' classes overtaking others. After age 7, improvement appears less heterogeneous, with classes following parallel tracks.

Tables 3 and 4 give descriptive information on the classes. Fifty-five per cent of the sample fell into the *Marked Delay* and *Very Low* classes (6 and 7) that started from very low scores and though continuing to improve throughout the 17-year period of observation, did so very slowly, with the larger *Very Low* class attaining a 2-year age equivalent and the smaller *Marked Delay* class attaining a 5-year age equivalent by age 19. The children in both groups began with the highest severity of autism and the lowest verbal and nonverbal IQ, though the nonverbal IQ of the *Marked Delay* class was a full standard deviation higher than that of the *Very Low* class.

The 22% of children in the *Catch-up* and *Partial Catch-up* classes (3 and 4) began the study with language comparable to the *Very Low* and *Marked Delay* classes, but made rapid gains by age 6, attaining age equivalents of 19 and 11 years respectively. In both cases, these trends in parent report are supported by direct assessment data on VIQ, and both groups started out with higher levels of nonverbal than verbal IQ. Both classes also showed similar intermediate levels of autistic symptoms (in the high ASD range), but these improved more in *the Catch-up* than the *Partial Catch-up* class.

The 18% of children in the small *Near Typical* and larger *Mild Delay* classes (1 and 2), while starting a little behind the expectation for a typical child,

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Table 3 Sample means (standard deviations) for nonautism measures

Class description	Whole sample	Class 1 Near typical	Class 2 Mild delay	Class 3 Catch-up	Class 4 Partial catch-up	Class 5 Late delay	Class 6 Marked delay	Class 7 Very low
N age 2	192	10	25	5	37	8	44	62
N age 19	106	4	15	3	21	5	26	32
Prevalence at 2		5%	13%	3%	19%	4%	23%	32%
Assignment certainty	89%	97%	90%	99%	88%	88%	82%	91%
Non-White	34%	20%	20%	0%	38%	25%	39%	39%
Female	15%	10%	8%	20%	8%	13%	28%	13%
Vineland Exp. AE years at 2	0.7 (0.5)	1.2 (0.7)	1.1 (0.4)	0.5 (0.5)	1.0 (0.4)	1.0 (0.6)	0.5 (0.4)	0.3 (0.3)
At 19	7.4 (7.7)	19.6 (4.9)	16.4 (7.2)	22.0[a] (0)	11.8 (6.4)	4.4 (0.9)	3.4 (1.4)	1.2 (1.0)
Vineland Rec. AE years at 2	0.9 (0.6)	1.7 (1.0)	1.4 (0.6)	0.8 (0.3)	1.1 (0.5)	1.6 (0.7)	0.7 (0.3)	0.6 (0.2)
At 19	7.8 (6.3)	18.0[a] (0)	12.8 (5.2)	18.0[a] (0)	11.0 (5.6)	8.9 (6.1)	5.7 (4.8)	2.5 (2.3)
VIQ at age 2	35.8 (21.9)	76.3 (24.4)	57.6 (24.1)	27.2 (6.4)	44.1 (16.6)	47.6 (21.7)	28.9 (11.0)	19.6 (6.8)
At 19	50.9 (42.6)	114.3 (12.4)	107.7 (18.0)	108.0 (7.1)	80.6 (27.6)	51.2 (30.5)	28.5 (13.6)	10.2 (6.9)
NVIQ at age 2	66.9 (21.8)	96.4 (10.8)	85.2 (20.0)	73.0 (9.0)	74.2 (15.5)	78.3 (16.1)	64.5 (15.4)	50.2 (18.6)
At 19	57.6 (40.9)	110.8 (12.3)	109.4 (15.0)	112.0 (8.5)	85.3 (28.4)	55.8 (40.3)	42.4 (22.0)	18.7 (13.7)
Vineland Daily Living SS at 2	68.5 (9.1)	83.5 (8.0)	72.8 (7.2)	70.0 (7.2)	68.9 (6.2)	74.4 (10.6)	66.3 (6.1)	63.3 (7.6)
At 19	62.6 (22.6)	91.0 (16.1)	87.7 (13.4)	95.3 (9.6)	77.0 (14.2)	59.6 (8.4)	56.2 (13.0)	39.8 (10.6)

AE, age equivalent; SS, standard score.
[a]Indicates where cell sample size is very low.

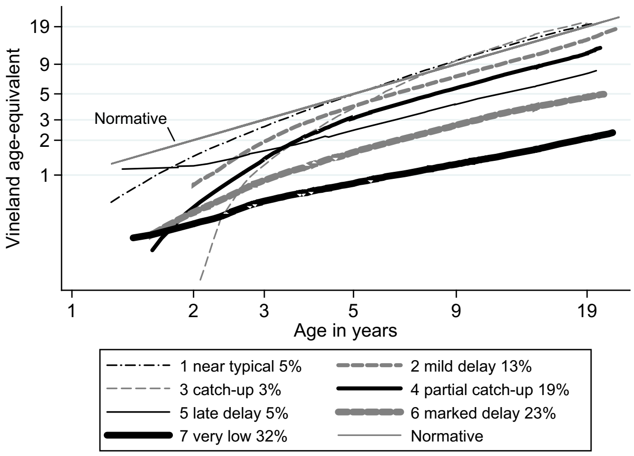

Figure 1 Lowess smooths for overall language (average of expressive and receptive) for the participants classified by the 7-class Type 3 model

largely caught up by age 3 and then continued on track, a development paralleled in both VIQ and NVIQ. These classes began with mild ASD symptomatology, and this appeared to become still milder by early adulthood, though direct comparison is complicated by change in ADOS module.

These groups can be contrasted with the 5% of children in the Late Delay class (5), who though starting out with comparable parent-report language abilities progressively fell behind to end up with an age equivalent of 8 years (at age 19). Their early relatively good parent reported early language was not strongly supported by direct assessment at that age.

Treatments were highly variable and hard to meaningfully summarize quantitatively. Table 4 shows data on early treatments. On average, the cohort received little language therapy and few children were able to participate in ABA or TEACCH, the more common 'intensive' therapies available. Taking into account the small size of some classes, there was no clear pattern of association of trajectory class and therapy.

Expressive–receptive differences

Figure 2 shows the class trajectories for a discrepancy ratio, the receptive minus expressive discrepancy scores divided by their mean score. Broadly speaking, these share a pattern in common of a declining discrepancy, but the three lower language ability classes maintain receptive scores higher than expressive, while for the remaining higher classes the discrepancy declines beyond the point of reversal to where expressive exceeds receptive. As shown in Table 2, imposing a model of Type 5 in which class differences in expressive language are a scaled version of those in receptive, appeared to provide a parsimonious description with nine fewer parameters and improved BIC. Overall, classes improving in one measure also improved in the other, but improvement in expressive exceeded receptive.

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Table 4 Sample means (standard deviations) for Autism and treatment measures

Class description	Whole cohort	Class 1 Near typical	Class 2 Mild delay	Class 3 Catch-up	Class 4 Partial catch-up	Class 5 Late delay	Class 6 Marked delay	Class 7 Very low
ADI-R at 2 Social	16.9 (5.9)	12.0 (6.2)	13.6 (6.0)	17.6 (4.7)	14.0 (5.9)	13.4 (5.8)	17.9 (5.6)	20.5 (3.6)
ADI-R at 2 Comm(NV)	9.0 (2.9)	6.4 (3.7)	7.1 (3.1)	8.8 (1.8)	7.5 (3.3)	8.4 (2.7)	9.9 (2.2)	10.6 (1.2)
ADI-R at 2 Rep/Stereo	3.5 (1.9)	2.8 (2.3)	2.8 (1.9)	3.4 (1.7)	3.5 (2.1)	2.6 (1.3)	3.5 (1.9)	4.2 (1.5)
ADOS at 2 Soc/Aff	11.0 (6.1)	10.3 (6.0)	11.2 (5.6)	16.5 (3.7)	12.3 (5.4)	12.7 (5.6)	16.0 (3.9)	18.5 (2.0)
ADOS at 19 Soc/Aff	11.7 (6.1)	1.5 (1.7)	5.4 (4.0)	4.5 (6.4)	9.0 (4.1)	10.2 (6.2)	13.9 (4.3)	16.8 (3.8)
ADOS at 2 Rest/Rep	2.8 (2.5)	2.5 (2.7)	1.9 (1.5)	5.0 (2.3)	2.5 (2.0)	3.2 (2.4)	4.2 (2.4)	4.5 (2.2)
ADOS at 19 Rest/Rep	3.0 (2.5)	0.5 (0.6)	1.3 (2.1)	0 (0)	2.2 (2.3)	2.7 (1.7)	3.8 (2.0)	4.4 (2.7)
DX at 2								
Autism	53%	10%	24%	100%	30%	50%	59%	79%
ASD	31%	50%	48%		49%	5%	32%	13%
DX at 19								
Autism	66%	0%	33%	0%	67%	80%	77%	84%
ASD	8%	0%	27%	0%	10%	0%	12%	0%
Language therapy (hr)	32.3 (36.4)	23.3 (31.2)	28.2 (26.6)	40.7 (42.0)	33.7 (43.8)	50.7 (23.2)	28.0 (26.7)	33.5 (42.8)
All individual treatment (hr)	101.4 (184.8)	73.7 (74.4)	69.7 (119.4)	149.7 (126.1)	84.3 (105.2)	147.3 (116.3)	91.1 (145.0)	125.0 (274.2)
ABA by age 3	12/180	0/9	1/22	2/5	1/35	1/9	3/42	4/58
TEACCH by 5	28/185	1/9	2/22	1/5	6/35	0/9	8/42	10/58

ADI-R, autism DIAGNOSTIC interview – revised; Comm (NV), nonverbal communication total score; Rep/Stereo, repetitive, restricted and stereotyped behaviour total score; ADOS, autism diagnostic observational schedule (various versions); Soc/Aff, social and affect total score; Rest/Rep, restricted and repetitive behaviours score; ABA, applied behaviour analysis therapy.

Discussion

Trajectory methods identify common or distinct patterns of variation after having stripped out occasion to occasion variation. Any one child will provide a record of measurements suggesting more change, both up and down, than evident from the trajectories shown in our Figures. What the models suggest is that this is haphazard variation that typically would not be maintained to the next assessment. It is tempting to overinterpret models of this kind, that in generating classes of subjects of one kind or another, we do not convey the uncertainty associated with there being alternative plausible classifications. We therefore focus on the gross features of the patterns that we have identified that are more likely to be reproducible in other studies.

In this ASD cohort, as others have found (Wodka, Mathy, & Kalb, 2013), two thirds of children achieve functional language exceeding a 3-year age equivalent. A substantial minority of children achieve adult language outcomes well within the typical range. The *Near Typical* and two 'complete' *Catch-Up* groups form 8% of the sample, similar to the 10% of children achieving rapid gains reported by Fountain, Winter, and Bearman (2012) using nine ASD-related items in a study of very different methodology. A further class of 13% of children were able to maintain a level of language corresponding to roughly 70% of their age equivalent throughout the period. These proportions

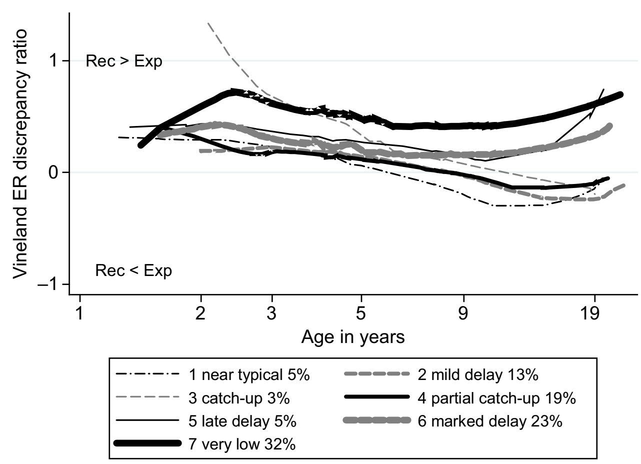

Figure 2 Lowess smooths for the receptive and expressive language discrepancy trajectories for participants classified by the 7-class Type 3 model

with successful outcomes are also likely to be an underestimate of the adult outcomes of children being currently identified with ASD, as more able children constitute a much higher proportion of those referred for ASD today than was the case in the late 1980s/ early 1990s when this cohort was recruited. The characteristics of these children are consistent with the finding that the strongest childhood predictor of 'optimal outcome' was rapid improvement in verbal IQ between age 2 and 3 (Anderson et al., 2014).

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It is striking that all the 'catch-up' growth exhibited by the *Catch-Up* groups was essentially complete by age 6. Beyond age 6, while absolute levels of language ability improved, the groups essentially maintained their relative standing, exactly as was the case in the Conti-Ramsden study of SLI children (Conti-Ramsden et al., 2012). We cannot say whether this evidence of qualitative heterogeneity in development before and after age 6 applies beyond children with an ASD to include SLI or even typically developing children, as so few studies span this age range. However, the finding is consistent with a number of other studies that investigated fragments of it (e.g. Bishop & Edmundson, 1987; Johnson et al.,1999; Law et al., 2008). Our models allowed for differential measurement error with age, so we do not believe that the greater variation at younger ages is an artefact of measurement error.

Various alternative explanations of the pattern of early change can be put forward. The diversity in development among the classes prior to age 6 could reflect nothing more than the unfolding or revealing of a set of different but fixed and preprogrammed capacities for language. Alternatively, the early period could be one of increased plasticity and the diversity of trajectories reflects children responding to a diversity of early environments, some more advantageous for learning language than others. Either way, beyond age 6, patterns of progress are uniform, with insufficient common variation in responsiveness of the language system and/or insufficient common variation among the children's environments to generate novel differential change. We have used the term common to emphasize that we have searched for patterns of development that are shared by a number of children and that these findings are not inconsistent with occasional case-reports that would contradict. The term also emphasizes how the variation in environments examined lies within the range of this naturalistic cohort, among whom treatment use was limited. Randomly assigned intervention studies that have focussed on communication have achieved substantial short-term change on targeted interactional behaviour (e.g. Green et al., 2010) but on language tests assessed blind (noting that parent report is rarely blind), effects are typically slight (Speckley & Boyd, 2009) or limited (Kasari, Paparella, Freeman, & Jahromi, 2008). But it cannot be overemphasized that the study we present here has no formal design to detect the effects of intervention. That progress beyond age 6 is uniform could be seen as an achievement of treatment rather than as a failure.

Overall, there was a tendency for expressive language to exceed receptive language as language competence grew. This perhaps reflects parents' perceptions of their children's use of language in a disinhibited or not purely communicative way. The Conti-Ramsden et al. (2012) study of SLI children also found a group with expressive higher than receptive language as Hudry et al. (2010) had found for preschool siblings of children with autism.

Our decision to use parent rated language may be criticized. However, the Vineland has strengths in relation to assessing language in a natural setting, the use of a single measure to span the range from proto to mature language, and the relatively few floor/ceiling effects compared to most more formal language measures. We have previously examined parental reports of expressive and receptive language from the Vineland from ages 2, 3 and 5 as well as direct assessment measures from age 2 to 9 (Anderson et al., 2007; Taylor, Pickering, Lord, & Pickles, 1998). The agreement between parent and direct assessment was considerable. In this longer study, direct assessment again supported the pattern of each parent-report trajectory class.

The great strength of this study is the ability to examine patterns of language development over such an extended period and within a well-characterized cohort. Inevitably, such a cohort reflects the circumstances prevailing at its inception and so the relative sizes of classes may be somewhat different among currently referred children. However, there is less reason to believe that the patterns of development are different, in particular that the greater variation in the rate of development of language evident in early life does not still apply to currently referred children.

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Key points

- Few articles have examined patterns of language development from inception to adulthood.
- We show that the pattern of variation before age 6 shows substantial heterogeneity in progress, some groups overtaking or falling behind others.
- Beyond age 6, all groups progress in a qualitatively similar manner, maintaining but not changing their relative progress.
- The findings are consistent with the view that change in language trajectory may be more easily achieved through intervention before rather than after age 6.

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