Early expressive and receptive language trajectories in high-risk infant siblings of children with autism spectrum disorder

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Abstract
Background & aims: In response to limited research on early language development in infants at high risk for Autism Spectrum Disorder (ASD), the current prospective study examined early expressive and receptive language trajectories in familial high-risk (HR) infants who were and were not later diagnosed with ASD (HR-ASD and HR-N, respectively), and low-risk (LR) controls with no family history of ASD.
Methods: Participants were 523 children (371 HR siblings, 56% boys; 152 LR controls, 52% boys) followed from age 6 or 12 months to 36 months. Based on independent, best-estimate clinical diagnoses at 36 months, HR participants were classified as HR-ASD (n = 94; 69% boys), or HR-N (n = 277; 52% boys); the sample also included 152 LR controls (52% boys). Expressive and receptive language trajectories were examined based on corresponding domain standard scores on the Mullen Scales of Early Learning (MSEL) at 6, 12, 24, and 36 months. In the combined sample of HR and LR infants, semi-parametric group-based modeling was used to identify distinct trajectories in MSEL standard scores.

Results: A 3-group solution provided optimal fit to variation in both expressive and receptive language, with the following patterns of scores: (1) inclining from average to above average, (2) stable-average, and (3) declining from average to well below average. For both expressive and receptive language, membership in these trajectories was related to 3-year diagnostic outcomes.

Conclusions: Although HR-ASD, HR-N, and LR control infants were in each trajectory group, membership in the declining trajectory (expressive and/or receptive) was associated with an ASD diagnosis.

Implications: Evidence of declining trajectories in either expressive or receptive language may be a risk marker for ASD in a high-risk sample.

Keywords
Autism spectrum disorders, language, development

Language and communication impairments are well documented in children with Autism Spectrum Disorder (ASD; see Eigsti, de Marchena, Schuh, & Kelley, 2011, for a review). However, there is marked heterogeneity in their language development, as approximately one in four affected children remain non-verbal (e.g., Tager-Flusberg, Paul, & Lord, 2005), while others are verbally fluent with relatively good comprehension (including those formerly identified as having Asperger syndrome). Language and communication include both later verbal or written language as well as earlier communication skills, such as physical gestures and pre-linguistic vocal behaviour (Crais, Watson, & Baranek, 2009; Ellawadi & Weismer, 2014; Miller & Lossia, 2013). Language skills are often categorized into output (termed ‘expressive language’) and input (termed ‘receptive language’). Expressive and receptive language development are not well understood in very young children with ASD because most are not diagnosed until the age of three years or older (Mandell, Novak, & Zubritsky, 2005). Some evidence of developmental language differences in the first two years of life in ASD has emerged based on both direct assessment (Barbaro & Dissanayake, 2012) and parent-rated questionnaires (Veness et al., 2012) in sub-samples drawn from large community-based studies. These community-based studies, while informative, are limited by small sample sizes (n < 30) and by diagnostic outcomes determined at two years of age (Barbaro & Dissanayake, 2012), when stability may still be unclear. Prospective studies of infants at high risk for ASD provide an ideal opportunity to gain further insights into very early language development in infants subsequently diagnosed with ASD.

Children who have an older sibling with ASD are at higher risk for ASD themselves, with a recurrence rate of approximately 20% (Ozonoff et al., 2011). Accordingly, siblings of children with ASD can be studied prospectively to investigate the early nature of this developmental disorder. Several longitudinal studies have examined the early development of high-risk (HR) infant siblings later diagnosed with ASD (hereafter, HR-ASD), relative to that of HR siblings not diagnosed with ASD (HR-N), and low-risk (LR) controls with no family history of ASD (e.g., Messinger et al., 2013; Zwaigenbaum et al., 2005). These longitudinal studies have reported impaired expressive and receptive language development in HR-ASD samples. Paul, Fuerst, Ramsay, Chawarska, and Klin (2011) found that HR siblings as a group displayed differences in early vocal behaviour, producing fewer consonants and consonant–vowel combinations than LR controls at nine months, and fewer speech-like vocalizations at 12 months. Additionally, Landa and Garrett-Mayer (2006) found that HR-ASD siblings achieved significantly lower scores than LR controls on the expressive and receptive language subscales of the Mullen Scales of Early Learning (MSEL; Mullen, 1995) at 14 and 24 months of age, and significantly lower scores than age-matched controls with language delay on the MSEL receptive language subscale at 24 months. Although these studies provide insight into language development in HR-ASD siblings, previous research tells us little about the developmental unfolding, or trajectories, of early expressive and receptive language in an HR sample.

In a notable exception, Landa, Stuart, Gross, and Faherty (2013) examined trajectories of social, motor
and language abilities in a sample of 235 HR siblings and LR controls from six to 36 months of age. Generalized estimating equations were used to compare three diagnostic groups: HR-ASD siblings diagnosed before 14 months of age, HR-ASD siblings diagnosed after 14 months of age, and children with no ASD diagnosis (HR-N and LR controls combined). All three groups showed similar expressive and receptive language abilities as measured by the MSEL at six months of age, but atypical trajectories emerged thereafter in both HR subgroups. All three groups showed gains in MSEL expressive and receptive language raw scores with age, but both HR groups had more gradually inclining developmental trajectories, and did not demonstrate the typical growth spurt in expressive language at approximately age 24 months that characterized the LR group.

Although informative, Landa et al.’s (2013) trajectory findings are constrained by having compared performance on a language measure based on predefined diagnostic groups. In contrast, novel trajectory procedures are based on data-driven approaches that yield developmental trajectories. Two key studies by Brian et al. (2014) and Landa, Gross, Stuart, and Bauman (2012) have examined the development of various skills in HR siblings and LR controls over time, including language abilities. Landa et al. (2012) used latent class growth analysis and Brian et al. (2014) used a trajectory procedure based on semi-parametric group-based modelling to examine developmental trajectories in language, cognitive and motor development that were not constrained by predefined diagnostic groupings. Each of these studies is described in further detail below.

Landa et al. (2012) examined early cognitive trajectories in a sample of 204 HR siblings from six to 36 months. This study assessed MSEL domain scores (including visual reception, fine motor, receptive language, and expressive language) at six, 14, 18, 24, 30 and 36 months. Latent class growth analyses revealed that a four-class model provided the best fit for the data, characterized by the following patterns of scores: (1) overall accelerated development, (2) advanced nonverbal skills, (3) delayed receptive language and motor skills and (4) overall delayed development. Landa et al. also found that 36-month diagnostic outcomes of HR-ASD ($n = 52$), broader autism phenotype ($n = 31$) and HR-N ($n = 121$) were related to children’s latent class membership. Specifically, they found that 42% of HR-ASD children were in class 4, 31% were in class 3, 25% were in class 2 and only 2% were in class 1.

Brian et al. (2014) also examined early cognitive trajectories in a sample of 424 HR siblings and LR controls. This study used MSEL Early Learning Composite scores, as measured at six, 12, 24 and 36 months. Findings from a trajectory analysis revealed three distinct cognitive trajectories characterized by the following patterns of scores: (1) inclining from average to high-average, (2) stable-average and (3) declining from average to the intellectual disability range. In addition, 36-month diagnostic outcomes of HR-ASD ($n = 77$), HR-N ($n = 233$) and LR controls ($n = 114$) were related to trajectory membership. Specifically, 34% of HR-ASD siblings were in the declining group, 51% in the stable-average group and 15% in the inclining group. In contrast, 8% of the HR-N group were in the declining group, 40% in the stable-average group, and 52% in the inclining group. Finally, 1% of the LR controls were in the declining group, 20% in the stable-average group, and 79% in the inclining group. Although there was variability across diagnostic groups, membership in the declining group was associated with an ASD diagnosis.

The trajectory analyses in Brian et al. (2014) and Landa et al. (2012) focused on overall cognitive development, whereas we were interested in assessing specific trajectories of language scores. It is not clear exactly how distinct expressive and receptive language trajectories might account for developmental variability in HR-ASD siblings, nor is it clear whether either of these language trajectories differentiated between HR-N siblings and LR controls, possibly suggestive of a broader ASD phenotype in language development for HR siblings without ASD outcomes.

Modelled after Brian et al. (2014), we used an overlapping but expanded dataset to investigate expressive and receptive language trajectories separately, using a data- (vs. diagnostic group-) driven analytic approach. Expressive and receptive language trajectories were examined using corresponding MSEL domain standard scores at six, 12, 24 and 36 months in a combined sample of HR siblings and LR controls. Based on previous research by Brian et al. (2014) and Landa et al. (2012), we hypothesized that, relative to the stable-average or inclining performance typical of LR controls and HR-N siblings, the HR-ASD group would have a higher proportion of members in trajectories showing declining language standard scores, indicating a relative slowing of development. We were also interested in whether those children who showed relative decline in expressive language would also show relative decline in receptive language, and vice versa. Therefore, as secondary analyses, we examined relations between expressive and receptive language trajectories, using a joint trajectory analysis. Given evidence of differences between language production and comprehension
in ASD, it is reasonable to expect varying trajectories as well. For example, Volden et al. (2011) found that children with ASD at earlier developmental stages exhibited relatively stronger expressive compared to receptive abilities (i.e., an ‘expressive advantage’), whereas children with ASD at later developmental stages showed the opposite pattern (i.e., the typically observed ‘receptive advantage’, Fenson et al., 1994). However, a recent meta-analysis of expressive and receptive language in ASD by Kwok, Brown, Smyth, and Cardy (2015) failed to find strong evidence in support of an expressive language advantage in ASD from zero to five years of age. Given the inconsistency in the literature, we had no specific hypotheses about whether children in our sample would show differences in expressive and receptive language trajectory group membership, but believed that this issue warranted further investigation.

**Method**

**Participants**

Data were obtained from a Canadian multi-site prospective study of HR infant siblings of children with ASD (Zwaigenbaum et al., 2005). Participants were 523 children (n = 371 HR, 56% boys and 152 LR, 52% boys) followed from six or 12 months to at least 36 months of age. All infants were born between 36 and 42 weeks gestation, weighed at least 2.5 kilograms at birth, and had no identifiable neurological or genetic disorders or severe sensory or motor impairments. Based on independent, best-estimate clinical diagnoses at 36 months of age, HR participants were classified as HR-ASD (n = 94; 69% boys) or HR-N (n = 277; 52% boys).

**Ethical considerations**

Permission to conduct this research was granted by the research ethics board at each site. Parental written consent was obtained for all participants.

**Procedure**

As part of an on-going prospective study, participants were assessed at multiple time-points, including six, 12, 24 and 36 months of age. Not all participants were seen at every time-point, but all participants were seen at least twice and always at 36 months (see Table 1 for sample sizes by diagnostic group at each time-point).

**Mullen Scales of Early Learning (MSEL).** The MSEL is a standardized assessment of developmental abilities, which yields raw and standard scores in five domains:

| Table 1. MSEL standard scores. |
|--------------------------------|
| HR-ASD siblings | HR-N siblings | LR controls |
|----------------|---------------|-------------|
| **Expressive language** | | | |
| 6 months | n = 35 | n = 123 | n = 80 |
| M = 90.14 | M = 91.21 | M = 92.31 |
| SD = 10.25 | SD = 11.33 | SD = 9.67 |
| 12 months | n = 78 | n = 228 | n = 132 |
| M = 89.96 | M = 96.56 | M = 100.35 |
| SD = 16.50 | SD = 18.31 | SD = 14.82 |
| 24 months | n = 83 | n = 240 | n = 141 |
| M = 88.74 | M = 102.51 | M = 114.43 |
| SD = 18.46 | SD = 16.12 | SD = 19.68 |
| 36 months | n = 91 | n = 271 | n = 150 |
| M = 87.67 | M = 104.64 | M = 111.75 |
| SD = 19.03 | SD = 14.19 | SD = 13.28 |
| **Receptive language** | | | |
| 6 months | n = 35 | n = 123 | n = 80 |
| M = 100.13 | M = 101.49 | M = 105.55 |
| SD = 10.84 | SD = 13.85 | SD = 9.29 |
| 12 months | n = 78 | n = 228 | n = 132 |
| M = 89.75 | M = 94.09 | M = 100.85 |
| SD = 15.64 | SD = 13.52 | SD = 12.12 |
| 24 months | n = 80 | n = 242 | n = 142 |
| M = 83.76 | M = 106.33 | M = 117.42 |
| SD = 23.13 | SD = 16.45 | SD = 12.96 |
| 36 months | n = 90 | n = 272 | n = 152 |
| M = 85.90 | M = 104.74 | M = 112.53 |
| SD = 20.54 | SD = 15.10 | SD = 14.98 |
| **Visual reception** | | | |
| 6 months | n = 35 | n = 124 | n = 80 |
| M = 97.47 | M = 100.53 | M = 102.57 |
| SD = 9.39 | SD = 13.32 | SD = 11.04 |
| 12 months | n = 78 | n = 228 | n = 132 |
| M = 101.73 | M = 107.17 | M = 112.63 |
| SD = 14.25 | SD = 14.55 | SD = 12.79 |
| 24 months | n = 83 | n = 243 | n = 142 |
| M = 91.45 | M = 107.33 | M = 116.09 |
| SD = 19.74 | SD = 16.36 | SD = 14.63 |
| 36 months | n = 93 | n = 272 | n = 152 |
| M = 92.19 | M = 115.45 | M = 121.70 |
| SD = 27.42 | SD = 18.82 | SD = 14.25 |
| **Fine motor** | | | |
| 6 months | n = 35 | n = 123 | n = 80 |
| M = 96.61 | M = 96.70 | M = 103.43 |
| SD = 14.76 | SD = 13.56 | SD = 13.71 |
| 12 months | n = 77 | n = 227 | n = 132 |
| M = 108.53 | M = 113.98 | M = 118.92 |
| SD = 16.03 | SD = 14.32 | SD = 11.00 |
Gross motor movements were based on DSM-IV-TR criteria (American Psychiatric Association, 2000), results from the ADOS and ADI-R, and expert clinical judgment, consistent with bestpractice guidelines (Zwaigenbaum et al., 2007). As outlined above, children were classified as HR-ASD, HR-N or LR controls. One LR control was diagnosed with ASD and excluded from further analyses.

### Analytic approach

**Expressive and receptive language trajectories.** Following Brian et al. (2014), we examined whether distinct expressive and receptive language trajectories were evident in the total sample of 523 children, based on MSEL expressive and receptive language standard scores at four time-points: six, 12, 24 and 36 months (see Table 1 for MSEL standard scores for each domain by diagnostic group at each time-point). In addition to expressive and receptive language, scores for visual reception, fine motor and gross motor domains are included for reference.

The Statistical Analysis System (SAS) Trajectory Procedure (PROC TRAJ) identifies groups of individuals who follow similar developmental patterns and estimates developmental trajectories that provide optimal fit to variation in scores across the multiple timepoints using semi-parametric group-based modelling (Jones, Nagin, & Roeder, 2001). The output provides multiple models, and the model with the lowest Bayesian information criterion (BIC) is considered to have the optimal fit for the data. This procedure also handles irregularly spaced measurements, and uses an imputation procedure to assign values for missing data (Andruff, Carraro, Thompson, Gaudreau, & Louvet, 2009). Separate analyses were conducted for expressive and receptive language.

| Table 1. (continued) |
|----------------------|
| HR-ASD siblings | HR-N siblings | LR controls |
| 24 months | n = 78 | n = 241 | n = 142 |
| M = 87.54 | M = 102.17 | M = 109.127 |
| SD = 17.95 | SD = 14.64 | SD = 14.62 |
| 36 months | n = 91 | n = 272 | n = 152 |
| M = 83.24 | M = 103.62 | M = 113.77 |
| SD = 22.57 | SD = 20.04 | SD = 18.85 |
| Gross motor | 6 months | n = 33 | n = 123 | n = 80 |
| M = 92.36 | M = 91.085 | M = 98.91 |
| SD = 12.03 | SD = 14.30 | SD = 12.16 |
| 12 months | n = 78 | n = 226 | n = 132 |
| M = 89.64 | M = 91.67 | M = 94.43 |
| SD = 19.41 | SD = 17.94 | SD = 16.62 |
| 24 months | n = 64 | n = 211 | n = 135 |
| M = 88.05 | M = 95.87 | M = 101.73 |
| SD = 17.46 | SD = 14.45 | SD = 12.44 |
| 36 months | N/A | N/A | N/A |

HR-ASD: high-risk infants diagnosed with autism spectrum disorder; HR-N: high-risk siblings not diagnosed with autism spectrum disorder; LR: low risk; MSEL: Mullen Scales of Early Learning.

Note: MSEL standard scores are reported by domain at each age by diagnostic group, and include the sample size, mean and standard deviation.

Expressive, receptive, visual reception, fine motor and gross motor skills (Mullen, 1995). Standard scores from the expressive and receptive language subscales, derived from T-scores, were used for our primary analyses. Both MSEL language subscales were administered at six, 12, 24 and 36 months of age.

**Autism Diagnostic Observation Schedule (ADOS).** The ADOS is a semi-structured observational assessment for ASD symptoms in the areas of communication, social interaction and repetitive behaviour (Lord et al., 2000). The ADOS was administered at 36 months.

**Autism Diagnostic Interview-Revised (ADI-R).** The ADI-R is a parent interview that assesses children’s social development, verbal and nonverbal communication, and restricted repetitive interests and behaviour (Lord, Rutter, & Le Couteur, 1994). The ADI-R was administered at 36 months.

**ASD diagnostic assessment.** At 36 months of age, independent, best-estimate clinical diagnoses of ASD were made by experienced clinicians blind to participants’ previous assessments. Individual diagnostic assessments were based on DSM-IV-TR criteria (American Psychiatric Association, 2000), results from the ADOS and ADI-R, and expert clinical judgment, consistent with best-practice guidelines (Zwaigenbaum et al., 2007). As outlined above, children were classified as HR-ASD, HR-N or LR controls. One LR control was diagnosed with ASD and excluded from further analyses.

**Differences between language trajectories.** We tested for differences in the intercepts and slopes between the expressive and receptive language trajectories in a pairwise fashion, using the Wald test (Jones & Nagin, 2007). These tests assess whether parameter estimates vary across trajectory groups. Tests of intercepts indicate whether there are differences in the starting points for the trajectory groups; trajectory models in these analyses were centred at the initial assessment at six months of age. Tests of slopes indicate whether there

Association of 36-month diagnosis with expressive and receptive language trajectories. We used Chi-square analyses to test whether particular diagnostic groups had higher representation in some language trajectories. Standardized residuals (SR) greater than ±1.96 indicate a difference larger than that expected by chance with a p value < .05 (Field, 2013).
are differences in the rates of change over time across trajectory groups.

**Dual expressive and receptive language trajectories.** Relations between the contemporaneously evolving expressive and receptive language trajectories were examined using a joint trajectory analysis of the corresponding MSEL domain standard scores. This analysis examines the joint or conditional probabilities of membership in corresponding expressive and receptive language trajectory groups (Jones & Nagin, 2007).

**Results**

**Separate expressive and receptive language trajectories**

A three-group solution provided optimal fit to variation in both expressive and receptive standard scores, characterized by the following patterns: (1) inclining from average to above average, (2) stable-average and (3) declining from average to well below average (see Figures 1 and 2). For the expressive language trajectories, 43% of the total sample was in the inclining group, 47% in the stable-average group and 10% in the declining group. For the receptive language trajectories, 43% of the total sample were in the inclining group, 46% in the stable-average group and 11% in the declining group.

Chi-square analyses indicated a significant association between 36-month diagnostic outcomes and both expressive, $\chi^2 (4, 523) = 121.16; p < .001$, and receptive language trajectory membership, $\chi^2 (4, 523) = 165.68; p < .001$. Specifically, for expressive language, 33% of HR-ASD siblings were in the declining group, 56% in the stable-average group and 11% in the inclining group. In contrast, 7% of the HR-N group were in the declining group, 54% in the stable-average group and 39% in the inclining group. Finally, 3% of the LR controls were in the declining group, 28% in the stable-average group and 69% in the inclining group. Similarly, for receptive language, 43% of HR-ASD siblings were in the declining group, 46% in the stable-average group and 11% in the inclining group. In contrast, 6% of the HR-N group were in the declining group, 54% in the stable-average group and 40% in the inclining group. Finally, 1% of the LR controls were in the declining group, 31% in the stable-average group and 68% in the inclining group. See Table 2 for a summary of the number of participants by diagnostic group in each of the three expressive and receptive language trajectories.

For expressive language trajectories, standardized residuals (SR) indicated that, when examining the proportion of children from each diagnostic group within...
the three trajectories, HR-ASD siblings had higher representation in the declining trajectory ($SR = 6.7$), and lower representation in the inclining trajectory ($SR = -4.8$). Conversely, the LR controls had higher representation in the inclining trajectory ($SR = 5.0$), and lower representation in both the stable-average ($SR = -3.3$) and declining ($SR = -3.0$) trajectories. The HR-N siblings did not have any SR greater than $\pm 1.96$ for the expressive language trajectories. Similarly, for the receptive language trajectories, SR indicated that the HR-ASD siblings had higher representation in the declining trajectory ($SR = 9.3$), and lower representation in the inclining trajectory ($SR = -4.8$). The HR-N siblings had higher representation in the stable-average trajectory ($SR = 2.0$). Finally, the LR controls had higher representation in the inclining trajectory ($SR = 4.7$), and lower representation in both the stable-average ($SR = -2.7$) and declining ($SR = -3.9$) trajectories. In summary, a trajectory of declining expressive or receptive language was associated with an ASD diagnosis, although many HR-ASD siblings were in the stable-average trajectories.

**Differences between language trajectories at six, 12, 24 and 36 months**

Wald tests were used to examine the differences between intercepts and slopes in expressive and receptive language trajectories. The inclining expressive trajectory intercept was not significantly different from that of the stable-average trajectory; however, the intercepts for the inclining and declining trajectories and for the stable-average and declining trajectories differed significantly. The linear slopes were significantly different among all three expressive trajectories, and the quadratic slopes for the inclining and declining expressive trajectories also differed significantly. This indicates that the three trajectories, as a whole, differed significantly from one another, although the inclining and stable-average trajectories differed only by linear slope.

A similar pattern was found for the comparison of receptive language trajectories. The inclining trajectory intercept did not differ significantly from the intercepts for the stable-average or declining trajectories; however, the intercepts for the stable-average and declining trajectories differed significantly. The linear slope of the declining trajectory was significantly different from those of both the inclining and stable-average trajectories; however, the linear slopes of the inclining and stable-average trajectories did not differ significantly. Quadratic slopes for the inclining and declining trajectories did not differ significantly (see Table 3 for a summary of these data).

**Dual expressive and receptive language trajectories**

The joint trajectory analysis of MSEL expressive and receptive language standard scores found that the two were very closely related. Specifically, all children in the declining expressive language trajectory were in the declining receptive language trajectory (100%) and the converse occurred in almost all cases (99%). Similarly, almost all children in the inclining expressive
language trajectory were in the inclining receptive language trajectory (94%) and vice versa (93%).

Discussion

The current study examined expressive and receptive language trajectories from MSEL domain standard scores at six, 12, 24 and 36 months in a large sample of HR siblings and LR controls. Three distinct trajectories characterized the development of both expressive and receptive language: (1) inclining from average to above average, (2) stable-average and (3) declining from average to well below average. As hypothesized, an ASD diagnosis was related to membership in the declining expressive and receptive language trajectories. It is important to note that membership in the declining trajectory does not necessarily imply regression, but rather indicates a slowing in developmental rate relative to the test normative sample.

Expressive and receptive language trajectories

Like Brian et al. (2014), we found that three trajectories provided the best fit for six- to 36-month changes in expressive and receptive language. Although HR-ASD siblings, HR-N siblings and LR controls were represented in each trajectory group, membership in the declining trajectories (both expressive and receptive) was associated with an ASD diagnosis. Brian et al. (2014) and Landa et al. (2012) reported that 34% and 42% of children with ASD, respectively, were in declining development groups. Similarly, the current study found that 33% of HR-ASD children were in the declining expressive language trajectory and 44%

Table 2. Expressive and receptive language trajectory membership by diagnostic group.

|                        | HR-ASD siblings (n = 94) | HR-N siblings (n = 277) | LR controls (n = 152) |
|------------------------|--------------------------|-------------------------|----------------------|
| **Expressive language trajectory group** |                          |                         |                      |
| Inclining trajectory   | n = 10                   | n = 108                 | n = 105              |
| % Dx group             | 10.63%                   | 38.99%                  | 69.08%               |
| % Trajectory group     | 4.48%                    | 48.43%                  | 47.09%               |
| Stable-average trajectory | n = 53                  | n = 149                 | n = 43               |
| % Dx group             | 56.38%                   | 53.79%                  | 28.29%               |
| % Trajectory group     | 21.63%                   | 60.81%                  | 17.55%               |
| Declining trajectory   | n = 31                   | n = 20                  | n = 4                |
| % Dx group             | 32.98%                   | 7.22%                   | 2.63%                |
| % Trajectory group     | 56.36%                   | 36.36%                  | 7.27%                |
| **Receptive language trajectory group** |                          |                         |                      |
| Inclining trajectory   | n = 10                   | n = 112                 | n = 104              |
| % Dx group             | 10.64%                   | 40.43%                  | 58.64%               |
| % Trajectory group     | 4.42%                    | 49.56%                  | 46.02%               |
| Stable-average trajectory | n = 43                  | n = 148                 | n = 47               |
| % Dx group             | 45.75%                   | 53.43%                  | 30.92%               |
| % Trajectory group     | 18.07%                   | 62.18%                  | 19.75%               |
| Declining trajectory   | n = 41                   | n = 17                  | n = 1                |
| % Dx group             | 43.62%                   | 6.14%                   | 0.66%                |
| % Trajectory group     | 69.49%                   | 28.81%                  | 1.69%                |

HR-ASD: high-risk infants diagnosed with autism spectrum disorder; HR-N: high-risk siblings not diagnosed with autism spectrum disorder; LR: low risk.

Note: The number of participants from the three diagnostic groups in each of the three separate expressive and receptive language trajectories is reported, including count, percentage of diagnostic group and percentage of trajectory group.

Table 3. Wald test results for expressive and receptive language trajectories.

| Comparisons                                      | Expressive language | Receptive language |
|--------------------------------------------------|---------------------|--------------------|
|                                                  | $x^2$               | $p$ value          | $x^2$               | $p$ value          |
| Intercepts for inclining and stable-average trajectories | 0.126               | .723               | 0.496               | .481               |
| Intercepts for inclining and declining trajectories | 17.741              | <.001              | 3.465               | .063               |
| Intercepts for stable-average and declining trajectories | 28.977              | <.001              | 12.198              | <.001              |
| Linear slopes for inclining and stable-average trajectories | 13.807              | <.001              | 3.599               | .058               |
| Linear slopes for inclining and declining trajectories | –                  | <.0001             | 14.351              | <.001              |
| Linear slopes for stable-average and declining trajectories | –                  | <.0001             | –                   | <.0001             |
| Quadratic slopes for inclining and declining trajectories | 40.814              | <.001              | 3.305               | .069               |
were in the declining receptive language trajectory. Although we found that membership in the declining trajectory groups predicted an ASD diagnosis, most children with ASD fell within the stable-average and inclining language trajectories (see Table 2).

**Expressive and receptive language dual trajectories**

We examined associations between the contemporaneously evolving expressive and receptive language trajectories, using a combined trajectory analysis. Given the inconsistency in the literature, we were unsure if children in our sample might show differences in expressive and receptive language trajectory group membership. We found that expressive and receptive language trajectories were so closely related that almost all children in the declining expressive or receptive language trajectories were also in the other. The same relation was true for the inclining trajectories. These findings provide support for a strong association between the early developmental trajectories of expressive and receptive language abilities as measured by the MSEL. Interestingly, this correspondence between expressive and receptive language during the first three years of life is seen across HR-ASD siblings, HR-N siblings and LR controls in all three trajectory groups. However, it remains unclear what happens to some preschoolers with ASD as they develop to result in an expressive advantage earlier in development, and a receptive advantage later on (Volden et al., 2011). It is important to note that differences in clinically referred samples and HR samples such as the one in the current study, may account for some differences between studies that rely on different sampling methods (Sacrey et al., 2017). Moreover, the studies used different language measures that may have differential sensitivity to receptive and expressive skills across age levels.

**Limitations and future research**

Given our focus on HR siblings with emerging ASD, we cannot assume that the present findings will apply to all children with ASD. However, evidence of declining language trajectories has also been reported in association with ASD in a community-ascertained LR cohort (Barbaro & Dissanayake, 2012), wherein gains in age-equivalent scores failed to keep pace with chronological development from 18 to 24 months, for both receptive and expressive language in the small sub-sample of toddlers who were subsequently diagnosed at two years of age. Furthermore, families who volunteered to take part in our longitudinal research may differ from the general population in terms of motivation and availability to be involved. This selection bias may explain why LR controls had higher MSEL scores relative to published norms. Additionally, although the MSEL includes valid language indices, it may be limited in its ability to identify subtle characteristics of language acquisition, and may not fully reflect language usage in everyday contexts. Moreover, it may not be sensitive to subtle developmental differences since a limited number of ‘data points’ can be collected at each developmental stage. It is also important to note that how we assess children’s language skills can impact the levels of individual variability over time (Eadie et al., 2014). Other measures designed to assess language specifically, such as the Preschool Language Scale, Fourth Edition (PLS-4; Zimmerman, Steiner, & Pond, 2002), or those that measure nonverbal social communication, such as the Early Social Communication Scales (Mundy et al., 2003) or the Communication and Symbolic Behavior Scales (Wetherby & Prizant, 2002), may provide more comprehensive coverage of early language and communication development and functioning. Future research might also include data from later in development to assess the longer-term outcomes of the different language trajectories. Finally, future research might identify factors that predict membership in the trajectories, especially in the stable-average and inclining trajectories for the children with ASD, to examine predictors of positive outcomes.

**Clinical implications**

Early language delays are often cited as the first concern of parents of children later diagnosed with ASD (e.g., Jónsdóttir, Sæmundsdóttir, Antonsdóttir, Sigurdardóttir, & Ólason, 2011). Loss of early language skills has been reported in 15% of children with ASD, compared with only 1% of children with Selective Language Impairment (SLI; Pickles et al., 2009). The current study suggests that any evidence of declining trajectories, in either expressive or receptive language standard scores, may be a risk marker for ASD in an HR sample. Early identification of ASD is important so children can access early intervention, as there is emerging evidence that this may be related to better outcomes (e.g., Landa, Holman, O’Neill, & Stuart, 2011; Pickles et al., 2016).

For all children, regardless of diagnosis, early language difficulties may worsen over time, as evidenced by the declining standard scores in the third trajectory for both expressive and receptive language. Children who receive an early ASD diagnosis and also demonstrate language delays at 12 and 24 months may
warrant targeted language interventions. Like previous work by Pickles et al. (2009), we provide further evidence that language abilities can plateau or even decline over time. However, it is important to note that membership in an inclining language trajectory does not rule out a diagnosis of ASD at 36 months, as some children on the autism spectrum may have strong early language abilities. HR-N siblings may also be at risk for language impairments even when they do not meet criteria for ASD. Therefore, it is important to monitor language development in all HR siblings, as they are at higher risk for language difficulties during the first three years of life.

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