Running head: Language growth in high-risk siblings.

Keywords: autism spectrum disorder, early language development, high-risk siblings, predictors

Language growth in very young siblings at risk for autism spectrum disorder.

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Declaration of interest: The authors declare that they have no conflict of interest.

Abstract

Background: Children with autism spectrum disorder (ASD) show substantial variability in their language development. Language problems are highly prevalent in these children. In addition, the quality of early language abilities contributes to the overall development of these children and is highly predictive of their adult outcome. Yet, little is known about language development in children at risk of ASD during the first years of life.

Aim: The current study aimed to compare early receptive (RL) and expressive (EL) language development in children at risk of ASD and determine predictors of language development.

Method and procedures: Developmental trajectories of RL and EL were investigated from 10 to 36 months of age in younger siblings of typically developing children (LR-sibs, *N*=30) and in younger siblings of children with ASD (HR-sibs, *N*=31) using the Mullen Scales of Early Learning. Furthermore, both child and demographic characteristics were examined as possible predictors of language development.

Outcome and results: Both groups showed similar growth curves for RL and EL and the majority of the children showed average (within +/- 1.5 SD of the mean) or above average language abilities. Nevertheless, the mean growth of EL was lower and the variation in growth of both RL and EL was higher in HR-sibs than in LR-sibs. Furthermore, early child characteristics were predictive of language development in both groups. Yet, some child characteristics seemed to be of more importance in HR-sibs than in LR-sibs. Consequently, lower nonverbal abilities at 10 months in both groups and a higher degree of ASD characteristics at 14 months in HR-sibs may be indicative of difficulties in language development.

Conclusions and implications: HR-sibs show more variation in their language development than LR-sibs during the first three years of life. The majority of HR-sibs however did not present with below average language abilities. Yet, early characteristics of ASD may be a red flag for difficulties in the language development of HR-sibs.

Key-words: autism spectrum disorder, early language development, high-risk siblings, predictors

What this paper adds?

Section 1: What is already known on this subject.

Language ability is an important element for the quality of life of individuals with ASD. Different studies indicate that younger siblings of children with ASD might also encounter considerable variability and possible problems in their language development, as is often the case in children with ASD. Yet, knowledge on early language development of these younger siblings during the first three years of life and on what factors may influence this development remains rather limited.

Section 2: What this study adds.

Our results confirm that HR-sibs, like children with ASD, show more variation in their language development than LR-sibs. This indicates that it will be harder to predict the developmental trajectory of language in HR-sibs as progress does not seem to be uniform in these children. In addition, HR-sibs also show slower development of expressive language. Although the majority of the children show average or above average language development, child characteristics around 10 and 14 months may be indicative of difficulties in language development. Demographic characteristics, on the other hand, do not seem to play a significant role in language development.

Section 3: Clinical implications of this study.

Below average language development is limited in HR-sibs. Still, it is important to acknowledge that HR-sibs may encounter below average language to a higher extent than LR-sibs. Early child characteristics are associated with language development in both groups but characteristics of ASD at 14 months seemed to be of more importance for language development in HR-sibs than in LR-sibs. Consequently, different early child characteristics can be important in light of early detection of language delays.

Introduction

Although language impairment is not included in the diagnostic criteria for autism spectrum disorder (ASD) in the last edition of the Diagnostic and Statistical Manual of mental disorders (DSM-5, American Psychiatric Association [APA] 2013), language problems are highly prevalent in young children with ASD (Boucher 2012, Rapin and Dunn 2003). Some children with ASD develop little or no language, while others might show delayed language acquisition, use atypical or idiosyncratic language (e.g., stereotyped and repetitive speech, echolalia and neologisms), have an atypical pattern of lower receptive to expressive language scores or exhibit impaired pragmatic abilities (Boucher 2012, Kwok *et al.* 2015, Naigles and Tek 2017). Language problems largely persist and are quite common in school-aged children with ASD. The profile of language impairment, however, changes with age (Rapin *et al.* 2009).

Language ability is, together with cognitive proficiency, a decisive element in the overall development and quality of life of individuals with ASD (Drumm and Brian 2013). Furthermore, the quality of early speech and language development is highly predictive of adult outcome (Magiati *et al.* 2014). The absence of speech at age five predicts the least optimal outcome, whereas children with higher age equivalents for communication skills at age five have a decreased risk of a negative outcome (Darrou *et al.* 2010). Research also shows that language development in ASD is most variable before the age of six and shows a uniform progression afterwards (Pickles *et al.* 2014). In this light, research uncovering early language development and possible related difficulties has the potential to enable early screening and may lead to timely access to language intervention (Drumm and Brian 2013, Tager-Flusberg 2016).

Most research regarding language development of individuals with ASD has occurred with preschoolers and school-aged children (Naigles and Tek 2017). Little is known about the early development of language by these children since it is difficult to diagnose ASD reliably before the age of two to three (Ozonoff *et al.* 2015). Prospective longitudinal studies following younger brothers and sisters of children with ASD, also called "high-risk siblings (HR-sibs)", prove to be a strong research design to reveal early language development prior to diagnosis (Drumm and Brian 2013). Different studies highlight that, because of the high heritability of the disorder, around 10-20% of HR-sibs are likely to develop ASD (Messinger *et al.* 2015, Szatmari *et al.* 2016). Moreover, a substantial subgroup (28%) of siblings that do not fully develop ASD, show a mild manifestation of the disorder, called the "broader autism phenotype" (BAP; Losh *et al.* 2008, Ozonoff *et al.* 2014) and/or other developmental problems such as social-communicative difficulties, delayed language development or an atypical general development/general developmental delay (Charman *et al.* 2017, Toth *et al.* 2007). Hence, it is not only important to look at early language development in HR-sibs who develop ASD, but also in HR-sibs who do not meet criteria for ASD as they too, may be at risk of developing language difficulties (Drumm and Brian 2013).

Language development in HR-sibs

The literature regarding early language development in HR-sibs with and without ASD is inconsistent in its findings. Most research involves the comparison of HR-sibs and younger siblings of typically developing children (low-risk siblings; LR-sibs), at a specific age (e.g., Charman *et al.* 2017). Diagnostic outcome of HR-sibs is often taken into account although different diagnostic criteria have been used (especially for BAP; e.g., Landa *et al.* 2012). Differences in receptive and expressive language have primarily been measured using the Mullen Scales of Early Learning (MSEL; Mullen 1995; e.g., Brian *et al.* 2014, Charman *et al.* 2017, Landa *et al.* 2012).

Research reporting on early language development mainly focuses on the presence of group differences within the age range of 6 to 36 months enabling us to take an ASD diagnosis into account (Garrido *et al.* 2017). HR-sibs, as a group, have scored significantly lower than LR-sibs for expressive language at 6 and 12 months and for receptive language between 12 and 27 months (Paul *et al.* 2011, Toth *et al.* 2007). The review of Garrido *et al.* (2017) confirms that starting from 12 months onwards lower scores in receptive and expressive language are found in HR-sibs. When a best estimate diagnosis of ASD at 18, 24 or 36 months was taken into account, findings were less consistent. Between 6 to 36 months, HR-sibs with and without ASD have scored significantly lower than LR-sibs on both receptive and expressive language, though not in all studies nor at all ages (Charman *et al.* 2017, Hudry *et al.* 2014, Landa and Garrett-Mayer 2006, Ozonoff *et al.* 2010). Lower receptive language scores are often reported at younger ages than lower expressive language scores (Ozonoff *et al.* 2010) and seem to show slightly higher effect-sizes (Garrido *et al.* 2017). In addition, Hudry *et al.* (2014) reported that reduced receptive language, or an expressive advantage, was seen at the age of 14 months for both HR-sibs with and without ASD. This indicates that relatively higher scores were seen for expressive language than for receptive language. By the age of 24 months, however, only HR-sibs with ASD still showed reduced receptive language abilities. In addition to studies evaluating receptive and expressive language at specific ages, both abilities have also been investigated using longitudinal analyses to explore the developmental trajectories of LR-sibs and HR-sibs (Brian *et al.* 2014, Landa *et al.* 2012, Longard *et al.* 2017). Trajectories of general development have been generated, based on cognitive, language and motor development ranging from 6 to 36 months, measured with the MSEL. Both Brian *et al.* (2014) and Landa *et al.* (2012) described an inclining group showing accelerated development and a stable group showing average or typical development. However, the authors reported different findings with regard to the declining group. While Brian *et al.* (2014) described one declining group, Landa *et al.* (2012) differentiated between general developmental delay and delay only seen in motor and receptive language abilities. Longard *et al.* (2017) built on the sample of Brian *et al.* (2014) and found the same three trajectories when only receptive and expressive language were taken into account. Although LR-sibs and HR-sibs with and without ASD were represented in each developmental trajectory, membership of the declining group was mainly associated with an ASD diagnosis (Brian *et al.* 2014, Landa *et al.* 2012, Longard *et al.* 2017). In conclusion, HR-sibs show a high variability in their language abilities and only a subgroup of these children face language delays (Charman *et al.* 2017). Nevertheless, language delays may occur both in HR-sibs with and without ASD (Longard *et al.* 2017, Marrus *et al.* 2018).

Predicting developmental language trajectories

The early developmental period is one of increased plasticity (Pickles *et al.* 2014). The diversity of developmental trajectories possibly reflects dynamic transactions between the individual and his/her environment (Botting 2005, Mandy and Lai 2016, Pickles *et al.* 2014). Consequently, language development is not an isolated process. It is influenced by demographic factors (e.g., child's gender, educational level of the mother, socio-economic status, family history) and/or other characteristics of the child's development (e.g., gross motor skills, nonverbal intelligence, social-communicative abilities) in typically developing children, late-talking children and children with Developmental Language Disorder (DLD) or ASD (Bello *et al.* 2018, Rescorla 2011, Tager-Flusberg 2016, Weismer and Kover 2015). In light of early screening and timely language intervention, it is therefore crucial not only to look into the growth trajectories of language as such but also to explore what factors, early in life, influence this trajectory (Tager-Flusberg 2016).

The current study

The present study aimed to observe the growth of receptive and expressive language in HR-sibs and LR-sibs from 10 till 36 months and to evaluate to what extent the growth curves differed between both groups. Based on previous research (e.g., Landa *et al.* 2012, Longard *et al.* 2017) we expected HR-sibs to show lower levels and slower growth of receptive and expressive language compared to LR-sibs. Additionally, we also expected more variability in language development of HR-sibs. We anticipated an increase in the variability of both receptive and expressive language development starting after the first year of life, but earlier and/or more pronounced in receptive than in expressive language (Garrido *et al.* 2017, Ozonoff *et al.* 2011).

Second, we aimed to evaluate the presence of below/above average receptive and expressive language in LR-sibs and HR-sibs at the age of 36 months. Limited and inconsistent findings were however reported concerning language abilities of HR-sibs with outcomes other than ASD (Drumm and Brian 2013, Garrido *et al.* 2017, Landa *et al.* 2012, Longard *et al.* 2017, Marrus *et al.* 2018). Nevertheless, we did not only expect to find a high variability in language development in HR-sibs with ASD, but also in HR-sibs with BAP. In HR-sibs with atypical development - characterized by developmental difficulties that are unrelated to the diagnostic criteria of ASD - we expected to see a higher occurrence of below average language as part of a general developmental delay, contrary to HR-sibs and LR-sibs with typical development for whom we expected to find average or above average language.

Finally, we aimed to determine whether the growth of receptive and expressive language could be predicted based on demographic and early characteristics of the child's development potentially leading to valuable information with regard to early diagnosis and intervention. With regard to demographic characteristics, gender and educational level of the mother will be taken into account (Marrus *et al.* 2018, Rescorla 2011, Tager-Flusberg 2016, Weismer and Kover 2015). In addition, nonverbal abilities and ASD features (social-communicative difficulties and repetitive and restricted behaviours) will be included as characteristics of the child's development (Marrus *et al.* 2018, Tager-Flusberg 2016, Weismer and Kover 2015). The educational level of the mother has not been consistently predictive of language growth in preschool children with ASD (Anderson *et al.* 2007, Weismer and Kover 2015). ASD severity, on the other hand, appeared to be predictive of both receptive and expressive language growth while cognitive abilities mainly seemed to predict expressive language growth in preschool children with ASD (Weismer and Kover 2015). In line with research of children with ASD, we expected that mainly child characteristics would be predictive of receptive and expressive language in HR-sibs.

Method

Participants

Participants included 31 younger siblings (or in one case, half-sibling) of children with ASD (high-risk siblings; HR-sibs) and 30 younger siblings of typically developing children (low-risk siblings; LR-sibs) matched on chronological age with the HR-sibs. Inclusion criteria for LR-sibs were full-term birth and no ASD within first-degree relatives. HR-sibs had no known genetic condition linked to ASD. Risk status confirmation for HR-sibs was provided by requesting and evaluating the official diagnostic report of the older sibling with ASD. The risk status of LR-sibs was confirmed using the Social Responsiveness Scale, Second Edition (SRS-2; Constantino and Gruber 2012) and Social Communication Questionnaire (Rutter *et al.* 2003). The scores of LR-sibs' older siblings on both screening instruments were not indicative of ASD related difficulties. In addition parents also indicated that none of the LR-sibs' older siblings had a developmental disorder or genetic syndrome. Both LR-sibs and HR-sibs had at least one parent who was fluent in speaking and writing Dutch. Within the total sample, 57 children were monolingual and 4 children were bilingual. Parents did not report significant hearing loss in any of the children. There were no significant group differences in the gender ratio of LR-sibs and HR-sibs nor with regard to the family's socio-economic status (SES), which was calculated by means of the Hollingshead four factor index (based on the parents occupation and education; Hollingshead 1975). The educational level of the mother did however differ between both groups and was significantly lower in HR-sibs when compared to LR-sibs (see table 1). The current study was part of a longitudinal prospective study of HR-sibs and LR-sibs during the first three years of life, with assessments at the ages of 5 months (T1), 10 months (T2), 14 months (T3), 24 months (T4) and 36 months (T5). For the current study, only T2 to T5 were taken into account since language development was not evaluated at T1. The protocol of this study was approved by the ethical board of the Faculty of Psychology and Educational Sciences of Ghent University. Participant characteristics are presented in table 1.

Table 1. Participant characteristics

	LR-sibs	**HR-sibs**	
Gender ratio (M:F)	17:13	13:18	$\chi^2(1) = 1.32$
	M(*sd*)		
Family SES	50.60 (7.86)	47.06 (11.03)	*U* = 389.50
Educational level mother	6.40 (.67)	5.71 (1.07)	*U* = 294.00**

Note. SES = socio-economic status (Hollingshead 1975), **p<.01.

Measures

All assessments were administered by qualified doctoral and postdoctoral researchers who were trained in administering and scoring the Mullen Scales of Early Learning (Mullen 1995) and Autism Diagnostic Observation Schedule – Second edition (Lord *et al.* 2012). Examiners were not blind to the risk status of the children.

Mullen Scales of Early Learning (MSEL). The MSEL (Mullen 1995) is a standardized test measuring gross and fine motor skills, visual perception and receptive and expressive language of infants and preschool children (0-68 months). Overall cognitive ability is presented by the Early Learning Composite (ELC), a standard score derived from the *T* scores of the aforementioned cognitive scales, with the exception of gross motor skills. The MSEL has demonstrated good internal consistency and test-retest stability (Mullen 1995). The MSEL was administered at the ages of 10, 14, 24 and 36 months.

Autism Diagnostic Observation Schedule – Second edition (ADOS-2). The ADOS-2 (Lord *et al.* 2012) is a semi-structured, standardized assessment of a child's social-communicative behaviour designed to elicit communication, social interaction, play/imaginative use of materials, and restricted and repetitive behaviours. Depending on the child's age and language level, either the toddler-module, module 1 or module 2 was administered. A chi-square test revealed no significant difference in ADOS module between LR-sibs and HR-sibs at 24 months ($\chi^2(1) = .00$, $p = 1.00$) and 36 months ($\chi^2(1) = 1.68$, $p = .20$). Calibrated severity scores were used for Social Affect, Repetitive and Restricted Behaviours and the total score (Esler *et al.* 2015, Hus *et al.* 2014) to account for differences in module administration and language level.

Procedure

HR-sibs were recruited through centres for developmental disorders, rehabilitation centres, home guidance services and parent support groups. LR-sibs were recruited through well-baby clinics and day-care centres. In addition, both HR-sibs and LR-sibs were recruited through Facebook and the website of the aforementioned longitudinal follow-up study. At T2, 58 families (30 LR-sibs, 28 HR-sibs) agreed to participate in the study. In the HR-group, another 2 families (HR 11 and HR 28) entered at T3 and one family (HR 23) entered at T4 (see table 3). At each time point, families were invited to participate in the follow-up study. This resulted in a minimum response rate of 93.33%.

Participant Characteristics

Starting at the age of 24 months, HR-sibs scored significantly lower than LR-sibs with regard to nonverbal abilities measured with the Mullen Scales of Early Learning (MSEL; Mullen, 1995) ($p < .05$ at 24 and 36 months). Nonverbal abilities were defined as the sum of raw scores on visual perception and fine motor skills of the MSEL. HR-sibs also displayed significantly more characteristics of ASD at 14 months (social affect (SA) and repetitive and restricted behaviour (RRB): $p < .001$), 24 months (SA: $p < .001$; RRB: $p < .1$) and 36 months (SA: $p < .01$; RRB: $p < .001$) as measured using the Autism Diagnostic Observation Schedule, 2nd edition (ADOS-2; Lord *et al.* 2012). Group comparisons of the ADOS-2 module that was administered, did not indicate significant differences between LR-sibs and HR-sibs at any age. Thus, these results indicate that HR-sibs differ significantly on SA and RRB when compared to LR-sibs but that this difference cannot not be due to the administration of different ADOS-2 modules. Table 2 presents the characteristics for each group across T2, T3, T4 and T5 on the different measures.

Table 2. Characteristics for each group on the different measures

		LR-sibs	HR-sibs	
		M (SD)		
T2 = 10 months	Chronological Age	10.26 (.59)	10.41 (.55)	$F(1, 55) = 1.04$
	MSEL – nonverbal	30.51 (2.91)	29.19 (3.10)	$U = 304.00$
T3 = 14 months	Chronological Age	14.32 (.51)	14.41 (.72)	$F(1, 54) = .31$
	MSEL – nonverbal	38.21 (2.10)	36.07 (3.95)	$U = 276.50$°
	ADOS-2 SA	1.43 (.90)	3.04 (2.10)	$U = 580.00$***
	ADOS-2 RRB	2.22 (1.93)	4.52 (2.05)	$U = 559.50$***
T4 = 24 months	Chronological Age	24.27 (.92)	24.51 (.83)	$F(1, 58) = 1.12$
	MSEL – nonverbal	53.14 (2.97)	50.08 (5.98)	$U = 284.50$*
	ADOS-2 module (toddler:2)	23:6	23:6	$\chi^2(1) = .00$
	ADOS-2 SA	1.62 (.78)	3.34 (2.02)	$U = 643.00$***
	ADOS-2 RRB	3.21 (2.27)	4.31 (2.83)	$U = 527.00$°
T5 = 36 months	Chronological Age	36.81 (.70)	37.50 (2.25)	$F(1, 57) = 2.50$
	MSEL – nonverbal	75.86 (5.53)	70.38 (9.64)	$U = 272.50$*
	ADOS-2 module (1:2)	4:25	8:21	$\chi^2(1) = 1.68$
	ADOS-2 SA	2.17 (.93)	3.76 (2.17)	$U = 607.00$**
	ADOS-2 RRB	3.31 (2.32)	6.52 (2.23)	$U = 704.00$***

Note. Chronological age is reported in months, MSEL-nonverbal = sum of raw scores on visual perception and fine motor skills on the Mullen Scales of Early Learning, ADOS-2 = Autism Diagnostic Observation Schedule 2nd edition, SA = calibrated severity scores on the social affect scale, RRB = calibrated severity scores on the repetitive and restricted behaviour scale, *F* = one-way ANOVA, *U* = Mann-Whitney U test, χ^2 = Chi-square test, °p<.10, *p<.05, **p<.01, ***p<.001.

Diagnostic classification for HR-sibs at T5

Following the assessment at T5, the diagnostic status of HR-sibs was determined using the ADOS-2 (Lord *et al.* 2012) at T3, T4 and T5, the ADI-R (Lord *et al.* 1994) at T5 and all other available information from all visits, combined with expert clinical judgement. Five children at T5 qualified for the diagnostic criteria of ASD according to DSM-5 (APA 2013), two of whom were also developmentally delayed (DD). Eleven children were categorized as BAP. One of these children with BAP also had a language delay (LD). Children categorized as BAP presented with subclinical characteristics of ASD which was defined as presenting with impairments on at least two elements of the first two diagnostic criteria for ASD according to the DSM-5 (APA 2013; 3 criteria regarding social communication and interaction, A domain; 4 criteria regarding repetitive and restricted behaviour, B domain; see table 3), though without other developmental problems that may explain these impairments. In the case of HR 13 (see table 3), a research classification of BAP was made instead of giving a best estimate diagnosis of ASD due to the presence of language delay and pronounced shyness that may better explain the impairments presented on the diagnostic criteria of ASD (APA 2013). In the case of five children, a categorization of atypical development was made when there was only LD, DD, verbal dyspraxia, behavioural problems or eating problems without difficulties related to the diagnostic criteria of ASD. Finally, eight children were evaluated as typically developing and in the case of two children diagnostic classification could not be determined due to insufficient clinical information. LR-sibs all showed typical development at T5. An overview of the diagnostic classifications for the HR-sibs is presented in table 3.

Table 3. Overview of diagnostic classifications for the high-risk siblings

	TP	Diagnostic classification	DSM-5
HR 1	T2	Broader Autism Phenotype	B1,B3,B4
HR 2	T2	Autism Spectrum Disorder	
HR 3	T2	Broader Autism Phenotype	A3,B1,B4
HR 4	T2	Typical development	
HR 5	T2	Atypical Development: Verbal Dyspraxia	
HR 6	T2	Broader Autism Phenotype	A1,A3,B1,B4
HR 7	T2	Autism Spectrum Disorder, Developmental Delay	
HR 8	T2	Autism Spectrum Disorder, Developmental Delay	
HR 9	T2	Typical development	
HR 10	T2	Autism Spectrum Disorder	
HR 11	T3	Atypical Development: Language Delay	
HR 12	T2	Autism Spectrum Disorder	
HR 13	T2	Broader Autism Phenotype, Language Delay	A1-3,B1,B2
HR 14	T2	Typical development	
HR 15	T2	Broader Autism Phenotype	A1-3,B1
HR 16	T2	/	
HR 17	T2	Typical development	
HR 18	T2	Broader Autism Phenotype	A2, A3
HR 19	T2	/	
HR 20	T2	Broader Autism Phenotype	A2,A3,B1,B2,B3
HR 21	T2	Atypical Development: Developmental Delay	
HR 22	T2	Typical development	
HR 23	T4	Atypical Development: behavioural and eating problems	
HR 24	T2	Typical development	
HR 25	T2	Broader Autism Phenotype	A1,A3,B1,B4
HR 26	T2	Typical development	
HR 27	T2	Broader Autism Phenotype	B1,B2,B4
HR 28	T3	Broader Autism Phenotype	A1-3,B1
HR 29	T2	Typical development	
HR 30	T2	Atypical Development: Verbal Dyspraxia	
HR 31	T2	Broader Autism Phenotype	A1-3

Note. HR = high-risk sibling, TP = time point on which the first assessment of the MSEL took place, T2 = 10 months, T3 = 14 months, T4 = 24 months, / = insufficient clinical information in order to determine diagnostic classification, for atypical development the specific problem(s) is (are) specified, DSM-5 = diagnostic criteria that were probably or definitely present in HR-sibs classified within the broader autism phenotype, A = impairments regarding social communication and interaction, B = impairments regarding repetitive and restricted behaviour.

Data-analysis

Preliminary analysis revealed few outliers in the data (i.e., values higher/lower than the mean +/- 3 times the standard deviation (*SD*). One LR-sib presented with high scores on the ADOS-2 at 14 months and one HR-sib presented with a low score for expressive language on the MSEL at 36 months. Since outliers were not considered to be random but characteristic of our sample, outliers were replaced by the highest/lowest value allowed (mean +/- 3*SD*) rather than deleted. Further, the limited number of missing data in this study (5.68%) was caused by fussiness or crying of the child or because the appointment was cancelled and could not be rescheduled in time (illness of the child, parents too busy). As expected missing data turned out to be completely at random (MCAR; Schafer and Graham 2002) given Little's test of MCAR versus MAR (Little 1988) was not significant ($\chi^2(144) = 119.32$, $p = .93$). Therefore we used all cases ($N = 61$) for all analyses.

First, univariate latent growth curve analyses were carried out for receptive and expressive language for HR-sibs and LR-sibs together. Thus far, no consensus has been reached on the number of participants necessary to perform growth curve analysis and samples as small as $N = 22$ (Huttenlocher *et al.* 1991) have been used successfully in fitting growth models (Curran *et al.* 2010). In addition, Curran *et al.* (2010) also indicated that a minimum of three repeated measures is preferred. Consequently, we believe that a sample of $N = 61$ with four repeated measures is sufficient to successfully fit a growth model. In a second step, the role of group status was evaluated using multigroup growth curve analyses. Given MCAR data robust Full information Maximum Likelihood (FiML) estimation was used. All growth curve analyses were performed with the statistical software package Mplus8 (Muthén and Muthén n.d.).

Second, factor scores for the individual levels and slopes of receptive and expressive language, based on their univariate growth curve, were saved and used for further analysis. Below/above average development in receptive and expressive language was explored for all children and briefly described related to diagnostic classification at T5.

Next, characteristics of the child's development and demographic characteristics were evaluated as predictors of the intercept and slope of receptive and expressive language. Characteristics of the child's development consisted of nonverbal abilities (operationalized as the sum of the raw scores on the MSEL subscales of visual perception and fine motor skills) at T2 and the degree of social-communicative difficulties and repetitive and restricted behaviour at T3 (both measured with the ADOS-2). They all represent the first time-point at which these characteristics were measured in the current study. This choice was made in light of early diagnosis and intervention. Demographic characteristics consisted of the child's gender and the mother's educational level (Hollingshead 1975). Predictors were chosen based on the literature with regard to significant factors influencing language development both in typical and atypical development (Bello *et al.* 2018, Rescorla 2011, Tager-Flusberg 2016, Weismer and Kover 2015). Given MCAR data, Expectation Maximization (EM) was used to impute missing values. First, correlations between the predictors and the intercept and slope of receptive and expressive language were inspected. Second, multigroup analyses were performed in Mplus8 (Muthén and Muthén n.d.).

Results

Longitudinal development of receptive and expressive language

The first key objective of this study was to examine the longitudinal development of receptive (RL) and expressive language (EL) and the role of group status within these.

A univariate latent growth curve model was estimated for RL and EL separately, based on the raw scores of the MSEL from T2 to T5. To assess the fit of the models, the chi-square test, the ratio of chi-square/degrees of freedom (normed *χ^2)*, the Comparative Fit Index (CFI), the Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean Square Residual (SRMR) were examined. A good model fit is indicated by a small chi-square, a normed χ^2 of around 2 or lower, a CFI of .95 or higher, a RMSEA value around .06 or lower, and a SRMR value of .08 or lower (Hu and Bentler 1999).

Receptive and expressive language. The fit indices and the mean and variance of the intercept and slope of the RL and EL model are presented in table 4. Because the initial model resulted in a relatively poor model fit, both for RL and EL, modification indices were inspected. These indices suggested adding a free parameter to the slope at T3 and T4 for both RL an EL and allowing a correlation between the residuals at T3 and T5 for EL. The adjusted model had good fit for both RL and EL as both models show a normed χ^2 lower than 2, a CFI higher than .95 and a RMSEA value lower than .06. Nevertheless, the range of the RMSEA is somewhat high and includes values larger than .06. Lastly, the SRMR value is lower than .08 for expressive language but not for receptive language. Taking this together, the majority of the fit indices are indicative of a relatively good model fit.

Table 4. Model fit indices, means and variances of the univariate latent growth curve analyses

	Receptive language	Expressive language
Model fit		
χ^2	3.304	0.786
normed χ^2	3.304/3 = 1.101	0.786/2 = 0.393
CFI	0.992	1.000
RMSEA	0.041	0.000
90% CI RMSEA	0.000-0.224	0.000-0.193
SRMR	0.126	0.023
Intercept		
M (SE)	12.34 (.23)	12.11 (.21)
s^2 *(SE)*	1.56 (.71)	.88 (.38)
Slope		
M (SE)	.79 (.02)	.86 (.03)
s^2 *(SE)*	.02 (.01)	.04 (.02)

Note. χ^2 = chi-square, normed χ^2 = ratio of chi-square/degrees of freedom, CFI = Comparative Fit Index, RMSEA = Root Mean Square Error of Approximation, SRMR = Standardized Root Mean Square Residual, M = mean, SE = standard error, s^2 = variance.

In a second step, the role of group status on the longitudinal development of RL and EL was investigated. To this end, multigroup analyses were performed evaluating whether similar developmental trajectories were found for RL and EL across LR-sibs and HR-sibs. For both RL and EL constrained models (i.e., models in which the parameters for the growth curve were held constant across groups) were compared to unconstrained models (i.e., models in which the parameters were allowed to vary across groups) evaluating the Satorra-Bentler scaled chi-square difference test (*SBS* $\chi^2 \Delta$). Modification indices were inspected starting from the constrained model.

Receptive language. Results revealed that group status played a moderating role in the univariate growth curve of RL, *SBS* $\chi^2 \Delta$ (1) = 25.81, $p < .001$. Modification indices indicated that group status moderated the variance of the slope. The variance of the slope was higher, although not significant, for the HR-sibs ($s^2 = .05$, $p = .07$) when compared to LR-sibs ($s^2 = .00$, $p = .40$). Visualization of individual estimated growth curves of RL for LR-sibs and HR-sibs is presented in figure 1.

Expressive language. Results revealed that group status played a moderating role in the univariate growth curve of EL, $SBS\ \chi^2\ \Delta$ (2) = 50.05, $p < .001$. Modification indices indicated that group status moderated the mean slope and variance of the slope. LR-sibs showed a significantly steeper slope ($M = 0.97$, $p < .001$) in comparison to the HR-sibs ($M = 0.75$, $p < .001$). The variance of the slope was also significantly higher for HR-sibs ($s^2 = 0.06$, $p < .05$) when compared to LR-sibs ($s^2 = 0.01$, $p = .11$). Visualization of individual estimated growth curves of EL in LR-sibs and HR-sibs is presented in figure 2.

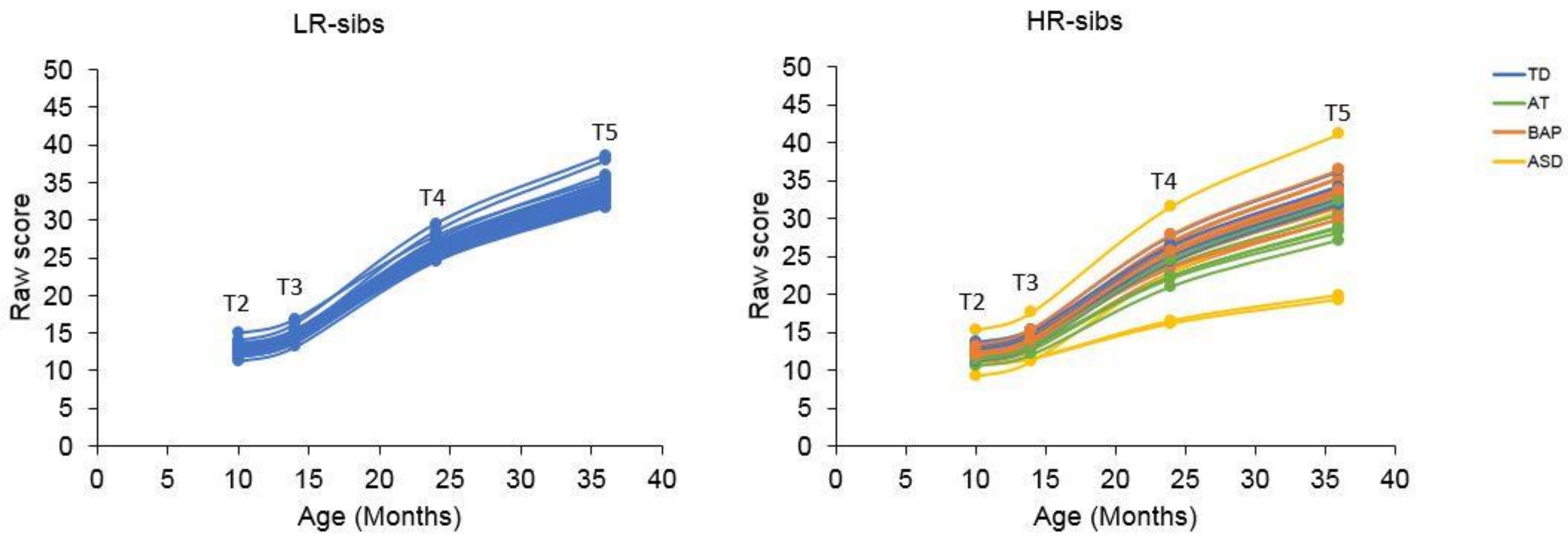

Figure 1. Estimated trajectories for receptive language from a univariate growth curve analysis. LR-sibs = low-risk siblings, HR-sibs = high-risk siblings, T2 = 10 months, T3 = 14 months, T4 = 24 months, T5 = 36 months, TD = typical development, AT = atypical development, BAP = broader autism phenotype, ASD = autism spectrum disorder.

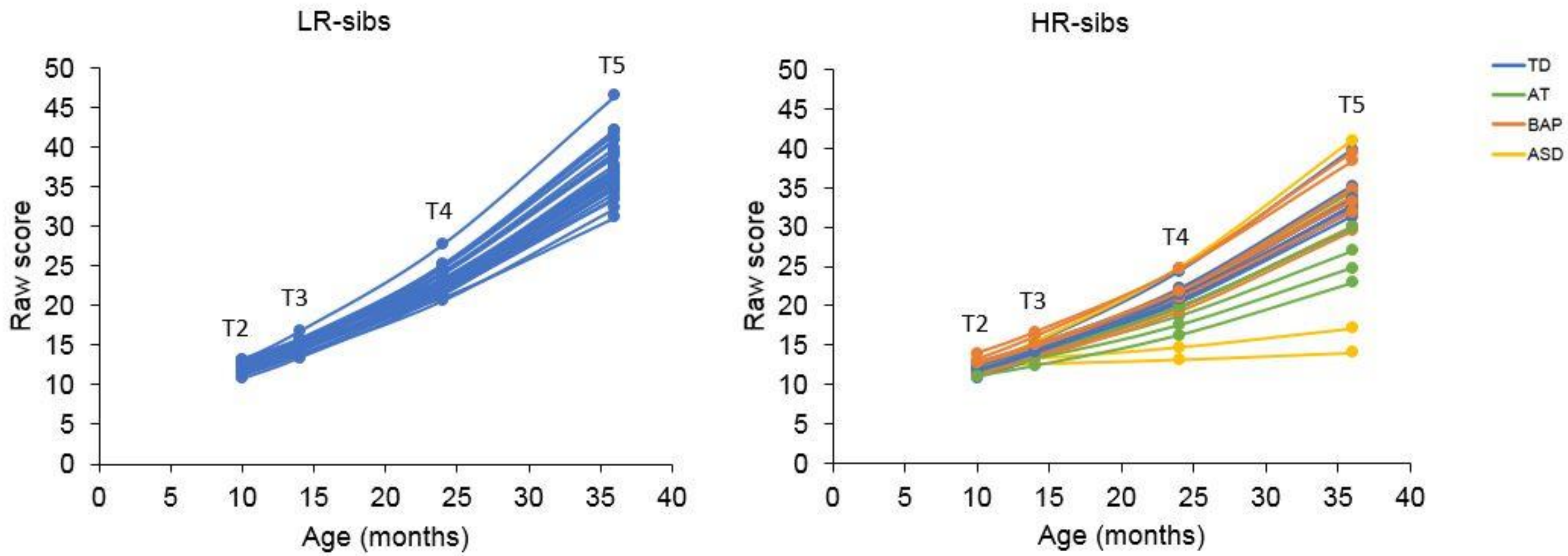

Figure 2. Estimated trajectories for expressive language from a univariate growth curve analysis. LR-sibs = low-risk siblings, HR-sibs = high-risk siblings, T2 = 10 months, T3 = 14 months, T4 = 24 months, T5 = 36 months, TD = typical development, AT = atypical development, BAP = broader autism phenotype, ASD = autism spectrum disorder.

Is below/above average receptive and expressive language present in LR-sibs and HR-sibs?

The second research question explored the presence of below/above average receptive and expressive language. Factor scores of the univariate growth curve model for RL and EL were used. Below/above average language development was defined at each time point as scoring 1.5 standard deviations below/above the mean.

For LR-sibs, above average language was observed at T4 and T5 in one child. All other LR-sibs showed average (within +/- 1.5 SD of the mean) language development. For HR-sibs, below average receptive language was observed at T2 for one child. Two other children showed below average expressive language, more specifically at T5 for one child and at T4 and T5 for the other child. Below average receptive and expressive language at T4 and T5 was seen in two other children. Above average receptive language development was seen in one child at T2 and T3. None of the HR children showed above average expressive language development. Language development that diverted (below/above) from average development was present in four HR-sibs with ASD and in two HR-sibs with atypical development. All HR-sibs who were classified as BAP or presented with typical development showed average (within +/- 1.5 SD of the mean) language development. In conclusion, all LR-sibs and the majority of HR-sibs (~84%) showed average or above average receptive and expressive language.

Predictors of intercept and slope in receptive and expressive language

The last research question explored the predictive value of demographic and child characteristics on the intercept and slope of RL and EL. Correlations between the predictors and the intercept and slope of RL and EL were explored. Child and demographic characteristics were included as predictors if they were significantly correlated in at least one group, if they were not significantly correlated but showed an inversed relation in both groups (positive correlation in one group versus negative correlation in the other group) or if they were significantly correlated in both groups when taken together. Correlation coefficients of LR-sibs and HR-sibs are presented in table 5.

Table 5. Pearson product-moment zero-order correlations

	RL		EL	
	Intercept	Slope	Intercept	slope
	LR-sibs			
NV T2	**.16**	**-.04**	**.35**[a]	**.04**
SCD T3	**-.29**	**.18**	-.06	**.29**
RRB T3	**.15**	**-.10**	**.05**	**-.10**
EL mother	-.15	**-.05**	-.08	**.25**[a]
Gender child	.28	**-.18**	.13	**-.02**
	HR-sibs			
NV T2	**.50****	**.35**	**.34**[a]	**.39***
SCD T3	**-.46****	**-.29**	-.32	**-.46***
RRB T3	**-.23**	**.15**	**-.19**	**.06**
EL mother	-.12	**.13**	-.25	**.07**[a]
Gender child	.12	**.10**	.01	**.18**

Note. RL = receptive language, EL = expressive language, LR-sibs = low-risk siblings, HR-sibs = high-risk siblings, NV T2 = nonverbal abilities measured at T2 (10 months), SCD T3 = social-communicative difficulties measured at T3 (14 months), RRB T3 = repetitive and restrictive behaviours measured at T3 (14 months), EL mother = educational level of the mother, *p < .05, **p < .01, [a] = significant predictors when both groups are taken together, predictors indicated in bold are implemented as predictors in the multigroup analyses.

Multigroup analyses were carried out for RL and EL separately containing predictors indicated in bold in table 5. Due to the small sample size, two separate models were performed with either child or demographic characteristics as predictors. For both RL and EL constrained models were compared to unconstrained models evaluating the Satorra-Bentler scaled chi-square difference test (*SBS* χ^2 Δ). Modification indices were inspected starting from the constrained model. When no moderation was present, the chi-square (χ^2) value of the constrained model was reported.

Receptive language

Child characteristics. Results revealed that group status played a moderating role on the child characteristics as predictors of the intercept and slope of RL, *SBS* χ^2 Δ (3) = 13.23, p < .01. Modification indices indicated that group status moderated the predictive value of repetitive and restrictive behaviours (RRB) at T3 on the intercept of RL and social-communicative difficulties (SCD) at T3 on the slope of RL. The correlation between intercept and slope of RL was also moderated by group status. The predictive value of RRB at T3 was negative in HR-sibs (β = -.29, p < .01) when compared to LR-sibs (β = .16, p = .36), but this was only significantly predictive of the intercept of RL in HR-sibs. The predictive value of SCD at T3 was negative in HR-sibs (β = -.30, p = .13) when compared to LR-sibs (β = .18, p = .12), even though SCD at T3 were not significantly predictive of the slope of RL in both groups. The correlation between intercept and slope of RL was significantly higher in HR-sibs (r = .46, p < .01) when compared to LR-sibs (r = .12, p = .55). Group status did not moderate the predictive value of nonverbal (NV) abilities at T2 and SCD at T3 on the intercept of RL. In both groups, the intercept of RL was positively predicted by NV abilities at T2 (β = .28, p < .01) and negatively associated with SCD at T3 (β = -.36, p < .01). The predictive value of NV abilities at T2 and RRB at T3 on the slope of RL was neither moderated by group status. The slope of RL was not significantly predicted by NV abilities at T2 (β = .02, p = .87) and RRB at T3 (β = -.02, p = .88).

Demographic characteristics. Group status did not play a moderating role on the demographic characteristics as predictors of the slope of RL, χ^2 (8) = 15.00, p = .06. The slope of RL was not significantly predicted by the educational level of the mother (β = -.00, p = .98) or the child's gender (β = -.09, p = .45) in both groups.

Expressive language

Child characteristics. Results revealed that group status played a moderating role on the predictors of the intercept and slope of EL, *SBS* χ^2 Δ (3) = 9.27, $p < .05$. Modification indices indicated that group status moderated the predictive value of RRB at T3 on the intercept of EL, SCD at T3 on the slope of EL and the correlation between intercept and slope of EL. The predictive value of RRB at T3 on the intercept of EL was negative, although not significant, in HR-sibs (β = -.16, p = .41) when compared to LR-sibs (β = .08, p = .61). The predictive value of SCD at T3 on the slope of EL was also negative in HR-sibs (β = -.50, $p < .01$) when compared to LR-sibs (β = .25, p = .06). Furthermore, the correlation between intercept and slope of EL was stronger in HR-sibs (r = -.30, p = .08) when compared to LR-sibs (r = -.06, p = .84), but this negative correlation was not significant in both groups. Group status did not moderate the predictive value of NV abilities at T2 and the intercept and slope of EL. In both groups, the intercept of EL was positively predicted by NV abilities at T2 (β = .37, $p < .01$), the slope of EL however was not (β = .12, p = .25). The predictive value of RRB at T3 on the slope of EL was also not moderated by group status. The slope of EL was not significantly predicted by RRB at T3 (β = -.01, p =.94).

Demographic characteristics. Group status did not play a moderating role on the demographic characteristics as predictors of the slope of EL, χ^2 (8) = 3.33, *p* = .91. The slope of EL was not significantly predicted by the educational level of the mother (β = .18, *p* = .18) or the child's gender (β = .07, *p* = .57) in both groups.

Discussion

The current study was the first prospective study that compared growth trajectories of receptive and expressive language in both LR-sibs and HR-sibs during the first three years of life and that investigated possible predictors of these trajectories.

Developmental language trajectories

Regarding the *first research question*, univariate growth curves were estimated for RL and EL separately, uncovering their trajectory and the possible role of group status herein. In general, HR-sibs and LR-sibs showed a similar curvilinear growth curve for RL as well as for EL. However, mean growth for EL was significantly lower and the variance of growth was significantly higher in HR-sibs. The variance of growth in RL also tended to be higher in HR-sibs. This shows that LR-sibs display a more uniform growth trajectory, while HR-sibs show more variability in their growth trajectory of RL and EL. This is in line with research in children with ASD reporting high variability in language abilities before the age of six (Pickles *et al.* 2014). Contrary to our expectations, which suggested earlier and larger delays in RL rather than in EL, a lower mean growth was only found in EL and not in RL (Garrido *et al.* 2017, Ozonoff *et al.* 2010). This might mean that HR-sibs as a group also show a receptive advantage, similar to typically developing children, rather than an expressive advantage as sometimes seen through children with ASD (Fenson *et al.* 1994, Kwok *et al.* 2015). Consequently, difficulties in language development will first be noticeable in expressive language (Laws and Bishop 2003, Paul *et al.* 2011, Weismer *et al.* 2010). Visual inspection of individual growth curves (see figure 2) shows similar EL development between both groups at 10 and 14 months, with diverging curves occurring between 14 and 24 months, continuing to 36 months. Despite the increase in variability starting between 14 and 24 months, all children still show similar curvilinear growth. This suggests that the possibility for persistent delayed language development might become apparent between 14 and 24 months of age. This is in line with the research of Landa and Garrett-Mayer (2006) who also reported a slower increase in language development occurring between 14 and 24 months in HR-sibs when compared to LR-sibs.

With regard to the *second research question*, variation in both receptive and expressive language was also seen when diagnostic classification at 36 months was taken into account. In LR-sibs, who all showed typical development at 36 months, mainly average language development was observed. Only one LR-sib showed above average expressive language at 24 and 36 months. Regarding HR-sibs, however, below or above average language was seen at different time-points but only in HR-sibs with ASD (with or without DD) or atypical development (DD with or without verbal dyspraxia), not in HR-sibs with BAP or typical development. This is only partly in line with previous research describing three to four different developmental trajectories in which LR-sibs and HR-sibs with and without ASD were represented (Brian *et al.* 2014, Landa *et al.* 2012, Longard *et al.* 2017). In the current study only HR-sibs with ASD or atypical development and LR-sibs were presented in different developmental trajectories. All HR-sibs with BAP, however, showed average development. This might be due to differences in defining BAP. Landa *et al.* (2012) operationalized BAP as having social or language delay, while the current study defined BAP as having subclinical characteristics of ASD. When looking into the individual growth curves of RL, below or above average RL occurred at 10 and 14 months for two HR-sibs with only ASD (and no DD) but this did not persist at older ages. In two HR-sibs with ASD and DD, below average receptive language was observed at 24 and 36 months. This might confirm that, in HR-sibs with ASD, low scores for RL may occur at an early age, yet, in contrast to previous studies, these differences did not persist at older ages in our sample except when also DD was reported (Garrido *et al.* 2017, Ozonoff *et al.* 2010). Below average EL, however, only occurred in HR-sibs who also have DD (with or without ASD). In conclusion, there were no HR-sibs (and LR-sibs) who showed an isolated language delay by 36 months in either RL or EL without general DD. This is in line with the research of Charman *et al.* (2017) stating that general developmental delay rather than language delay was more prevalent throughout HR-sibs without ASD outcome compared to LR-sibs.

Predicting developmental language trajectories

Concerning the *third research question*, predictors of the intercept and slope of RL and EL were explored. The intercept of RL was positively predicted by nonverbal abilities at 10 months and negatively predicted by social-communicative difficulties at 14 months in both groups. The predictive value of repetitive and restrictive behaviours at 14 months and the intercept of RL, however, differed between both groups and was only significant in HR-sibs. Nonverbal abilities at 10 months were also significantly predictive of the intercept of EL in both groups. The predictive value of social-communicative difficulties at 14 months and the slope of RL and EL differed between both groups, but this was only significant in HR-sibs regarding the slope of EL. These results indicate that in HR-sibs, similar to children with ASD, mainly child characteristics and more specifically nonverbal abilities and characteristics of ASD predict initial levels and growth in receptive and expressive language (Rescorla 2011, Tager-Flusberg 2016, Weismer and Kover 2015). Demographic characteristics did not seem to be related to later language development in both groups, which is in line with the research of Weismer and Kover (2015) in children with ASD. Lastly, the correlation between the intercept and slope of RL differed between both groups and was only significant in HR-sibs. This shows that HR-sibs that start with higher levels of RL also show higher growth in RL than LR-sibs that start with similar levels of RL. The abovementioned results confirm the importance of uncovering what factors may influence the intercept and slope of RL and EL of HR-sibs. Timely intervention working on these factors might lead to better results for HR-sibs. HR-sibs presenting with higher starting levels of receptive language might also experience this as a facilitating factor, even if they might develop ASD.

Clinical implications

From a clinical viewpoint, the current findings confirm that HR-sibs do not only show a higher risk for ASD, but they also show more variation in their language development than LR-sibs. Consequently, it will be harder to predict the developmental trajectory of receptive and expressive language in HR-sibs as progress does not seem to be uniform in these children. As seen in Charman *et al.* (2017), the majority of HR-sibs did not show a significant language delay at 36 months. Persisting below average language was only seen when a general developmental delay was also present. It is therefore important that HR-sibs are also seen as a risk group for general developmental difficulties that may partly consist of below average receptive and/or expressive language. The current study also reported that the trajectory of HR-sibs' receptive language development was determined by its intercept. This suggests that detection of slower receptive language development might already be possible during the first year of life. Besides early identification of slower language development, it is also important to uncover what factors may be related to language development. Child characteristics were significantly predictive of receptive and expressive language in both groups, yet some were only predictive of language development in HR-sibs. In HR-sibs, the intercept of receptive language was negatively influenced by repetitive and restrictive behaviours and the slope of expressive language was negatively predicted by social-communicative difficulties. It is possible that engagement in repetitive and restrictive behaviour may impede language development as infants whose focus is consumed by this type of behaviour may be less likely to take up social learning activities (Iverson 2010, Larkin *et al.* 2017, Leekam *et al.* 2011). In addition, previous research indicated that difficulties regarding social communication (e.g., use of gestures such as showing, pointing and giving) also seem to disturb language development as they may alter a child's access to interactions facilitating language (Adamson *et al.* 2009). More specifically, modifications in gesture development seem to elicit different responses of caregivers which may distinctively influence language development (Choi *et al.* 2018, Iverson 2010, Karasik *et al.* 2011, 2014, Libertus and Violi 2016). Furthermore, the coordination of these social-communicative abilities with vocalisations/language may prove to be important for subsequent language development (Heymann *et al.* 2018, Parlade and Iverson 2015). Consequently, it can be important to evaluate these child characteristics of HR-sibs at an early age. Intervention in this domain might not only stimulate social-communicative abilities, it might also benefit HR-sibs' subsequent language development. Additionally, being alert for repetitive and restrictive behaviours early in life might help detect HR-sibs with slower receptive language development.

Strengths and limitations

An important strength of the current study was the longitudinal prospective design in which LR-sibs and HR-sibs were followed during the first three years of life. Both groups were tested on a regular basis and with a standardised test battery, making it possible to map the development of language during its emergence. A second strength of the current study entails that HR-sibs were thoroughly evaluated at the age of 36 months, making it possible to take outcome (ASD, BAP, atypical development and typical development) into account. Despite these strengths, different limitations should also be discussed. First of all, there are some limitations related to using the MSEL for the evaluation of early language development. The research of Akshoomoff (2006) indicated that the MSEL was conducive for the evaluation of early language in children with ASD. Yet, they also reported that children with ASD may encounter specific difficulties (e.g., less engagement, difficulties with imitation skills, low motivation) during the administration of the MSEL that may have an influence on their obtained scores (Akshoomoff 2006). In addition, the MSEL might measure various aspects of early language in a rather limited way and may include less advanced expectations than other measures (e.g., the Vineland Adaptive Behaviour Scales (VABS; Sparrow *et al.* 2005) evaluates the use of phrases with a noun and a verb while the MSEL only requires two unspecified words for the use of phrases) (Luyster *et al.* 2008). Second, analyses based on outcome were only possible in a descriptive way due to the relatively small sample size. An additional limitation due to small sample size, is the modest generalizability of the results. Results will be fairly representative for HR-sibs as a group, yet not for the different outcome groups. Furthermore, it was only possible to include a limited number of predictors in the multigroup models, thereby possibly missing important factors contributing to language development.

Finally, potential significant correlations between predictors and the intercept and slope of RL and EL might have been missed due to the small sample size. More research looking into language development using longitudinal designs is needed, especially with regard to outcome in order to confirm that ASD is not necessarily accompanied by language difficulties. Furthermore, more predictors, specifically selected in light of language development, should be implemented in future research, in order to uncover protective and risk factors for later language development of HR-sibs.

Conclusion

This study provided new insights into the development of RL and EL in LR-sibs and HR-sibs. Both groups showed similar growth curves for RL as well as EL. However, group status influenced the mean growth of EL and the variation in growth of both RL and EL. The majority of HR-sibs did not display below average language development, yet it is still important to acknowledge that these children are at risk for below average language. The trajectory of HR-sibs' receptive language development was determined by the intercept, making it possible to detect slower development during the first year of life. Furthermore, different child characteristics were predictive of language development in LR-sibs and HR-sibs, yet, characteristics of ASD seemed to be of more importance in HR-sibs. Consequently, specific child characteristics at 10 and 14 months might be a red flag in HR-sibs signalling slower language development. Given the high variability of RL and EL in HR-sibs, future research should focus on evaluating different trajectories of language development in HR-sibs, both as a group and with regard to their outcome. In addition, there should also be a focus on predictors of language development in order to optimise early interventions.

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