Prelinguistic Intentional Communication and Subsequent Language Development in Infants with Possible Emerging Autism

Stefanie Dimov

B.Psych (Hons)

Submitted in total fulfillment of the requirements for

the degree of Master of Psychological Science

This work was supported by an Australian Government Research

Training Program Scholarship

Olga Tennison Autism Research Centre, School of Psychology and Public Health

La Trobe University

Victoria, Australia

August 2020

Contents

Abstract

Literature Review

Language development facilitates the communication of feelings and needs for children with others in their environment. While impairments in language abilities are not required for a diagnosis of autism, it has been estimated that between one-third of children and one-half of adults with autism fail to develop functional speech. Research also suggests that language delays in children with autism have implications for later social and adaptive functioning and long-term consequences for wellbeing and mental health. Marked impairment in prelinguistic intentional communication – including limited joint attention skills and gesture use –are among the earliest and clearest indicators for autism and predictive of subsequent language ability. To date, much of the literature linking prelinguistic intentional communication to subsequent language ability relies on retrospective or high-risk infant sibling methods and has utilised varying language measures. These factors make direct comparisons between studies difficult. It is also challenging to discern to what extent findings generalise to the wider population of children with autism in the community.

Aims and Hypotheses

The overarching aim of this study was to investigate the predictive relationship between early prelinguistic intentional communication skills/difficulties with later language development in the context of a cohort of infants with possible emerging autism, identified from the community. Specifically, the aims of this study were to: 1) profile the early prelinguistic intentional communicate abilities – that is, joint attention skills and gesture use – and receptive and expressive language abilities

of infants with possible emerging autism, and 2) evaluate the predictive value of early prelinguistic skills for subsequent language development across a one-year follow-up period.

Methods

Data for this study was available from a larger prospective longitudinal study of infants identified with possible emerging autism. Participants retained for analysis here were 72 infants, including 65.28% males, of mean age 11.72 months (range 9 to 16 months) at first assessment. Parent-report and direct assessment measures of joint attention skills and gesture use were collected at infants' baseline assessment, as was a measure of autism symptom presentation. Parent-report and direct assessment measures of receptive and expressive language ability were collected at both baseline assessment and one-year follow-up.

Results

Examination of descriptive statistics showed a 2-3 month receptive and expressive language delay for the infants, as a group, compared to language assessment norms. This delay was consistent at both baseline and follow-up, showing an average delay when compared to age-standardised norms. Correlational analyses demonstrated the multiple measures of language to be moderately to highly correlated (range: r=-.01 -.71). Baseline gesture use was significantly associated with both concurrent and prospective receptive language (range: r=31 - .44) and expressive language (range: r=27 - .52) abilities. However, no such significant associations were found with language ability for either response to joint attention (RJA) or initiation of joint attention (IJA) skills, at either time point. Finally, hierarchical linear regression analyses on language outcomes indicated that baseline language ability and autism symptoms were unique significant predictors of receptive (unique variance ranging between 6% and 11%) and expressive language (unique variance ranging between 6% and 14%).

Discussion and Conclusion

These results confirm the importance of gesture use as a specific prelinguistic intentional communication skill important in the development of language for young children and extends from previous literature to children with emerging autism. These are also some of the first results showing the importance of supporting language development in a group of children identified in infancy as having possible emerging autism. Furthermore, findings also demonstrate the importance of early autism symptoms in predicting subsequent language ability. These findings have implications for tailoring identification processes and early intervention to meet the language needs of children with emerging autism during the first two years of life. Future research could explore a larger number of prelinguistic communicative skills as predictors of subsequent language ability over a longer follow-up time period in various samples of children such as children with emerging autism, established autism and children with language/developmental delays.

Thesis Overview

Chapter 1 of this thesis is a literature review outlining the importance of language skills and early prelinguistic intentional communication skills for typically developing children and children with autism, including outlining gaps in the literature to provide a rationale for this thesis and the study aims and hypotheses.

Chapter 2 presents a discussion of methodological considerations for this thesis, including outlining the specific research procedure and design, summary of participants, and description of measures used. Chapter 3 reports findings relating to the study hypotheses. Finally, Chapter 4 provides a discussion linking the current study findings to the existing literature, including a consideration of strengths and limitations, and providing suggestions for future research.

Statement of Authorship

Except where reference is made in the text of the thesis, this thesis contains no material published elsewhere or extracted in whole or in part from a thesis accepted for the award of any other degree or diploma. No other person's work has been used without due acknowledgment in the main text of the thesis. This thesis has not been submitted for the award of any degree or diploma in any other tertiary institution.

Stefanie Dimov

26 August 2020

Acknowledgments

To my **supervisors** *Associate Professor Kristelle Hudry* and *Professor Teresa Iacono* – I cannot begin to thank you enough for the continued support, encouragement and wisdom. *Kristelle* – it has been a wonderful journey into academia from that first meeting in my third-year undergraduate degree to now. I will be forever grateful for your investment in me these last few weeks and to both of you for supporting me over the course of this degree.

To my **colleagues** at the Olga Tennison Autism Research Centre, especially *Lacey Chetcuti* and *Alex Aulich*. *Alex* – thank you for all your words of encouragement and general looking out for us AICES folk. And *Lacey* – my study pal. Thank you for the chats about research and life, coffees and long hours in the lab. You are a true star and I can't wait to see everything you're going to achieve.

To my **mentors** over the years:

Dr Lisa Mundy – thank you for your practical advice and for being an inspiration of the kind of academic I hope to be one day.

Professor Anne Kavanagh – thank you for teaching me about the truly important things and for believing in me from the get-go.

My *DHU family* – Thank you for being such a wonderful team to work with. Special thank you to *Anna Scovelle* (for ensuring I never felt alone during this process!), *Marissa Shields* (awesome office pal), *Dr Alex Devine* (thank you for your wisdom and care), and *Dr Ashley McAllister* (thank you for being such a great colleague and mentor, and for always knowing what to say).

Finally, *Associate Professor Allison Milner*. You were one in a million. I will always remember our chats about this thesis and unconventional academia. I will forever be grateful for the love of academia you have instilled in me. I miss you and hope to continue at least a small proportion of your legacy in the work I do.

To my dear **friends**, *Elisha* and *Katie*. Thank you for always understanding when I'm missing in action for days on end writing, for the endless hugs (pre-COVID) and messages of encouragement. I couldn't ask for better friends to be sharing all these experiences with.

To my **family**, thank you to *Dad* and *Mikael* for keeping me on my toes by continuing to ask me what it is I do. In all seriousness, thank you dad for keeping me nourished on my way into campus and Mikael for helping me download bits and bobs at short notice over the years. To my second family, Mumma *Mary* and my adopted sister-*Steph*. Thank you for always celebrating me, being patient and checking in with me.

To my **PB**, *Paul Butera*. Thank you for always pushing me to be better and to continue to love me even when this journey has been in no way glamourous. You are so smart and supportive, and I couldn't ask for a better role model. You're the reason I strive to be better at what I do every day. Thanks for being the best lockdown partner anyone could ask for.

Lastly, my **Ma**, *Mum*. Thank you for giving me no other option but to do tertiary study all those years ago. I can't thank you enough for all my drafts you've read, reference lists you've checked with an eagle eye and being someone knowing more about what I study than I do. It is no understatement to say I wouldn't be where I am if it weren't for you. You have taught me that it is not what you know, or even who you know, but *how* you know. I've learnt a lot about resilience and just getting on with it and will be forever grateful.

List of Figures

List of Tables

Chapter 1: Literature Review

Introduction

Autism Spectrum Disorder (ASD; hereafter, *autism*) is a neurodevelopmental disability characterised by impairments in social-communication skills and the presence of restricted and repetitive behaviours and interests (American Psychiatric Association, 2013). Prevalence estimates vary globally but recent reports have estimated that almost 1 in 60 children have autism in Australia (Bent et al., 2015) and the mean age of autism diagnosis nationally has been reported as 4 years and 1 month among young children (Bent et al., 2015). While impairments in language abilities are not required for a diagnosis, it has been estimated that between one-third of children (Bryson, 1996) and one-half of adults with autism (Norrelgen et al., 2015) fail to develop functional speech. Furthermore, studies of children with autism have shown that early language has implications for later social and adaptive functioning (Anderson et al., 2007; Luyster et al., 2008; McDuffie et al., 2005) and long-term outcomes in wellbeing and mental health (Gillespie-Lynch et al., 2012; Howlin et al., 2004). Given that the presence of functional speech in early childhood is a strong predictor for better outcomes in autism, and that the average age of autism diagnosis in Australia is relatively late in the early childhood period (i.e., around 4 years), it is important to investigate verbal and preverbal precursors of language development in young children during the period when autism may be emerging. Emerging autism relates to autism symptoms developing in toddlerhood, prior to when a reliable autism diagnosis is made (Elsabbagh et al., 2013), and is measured utilising instruments such as the Autism Observation Scale for Infants (Bryson et al., 2008) and the Autism Diagnostic Observation Schedule – Toddler Module (Luyster et al., 2008), developed for measuring autism symptoms in toddlerhood. A clearer understanding of disruptions to the normative process of language development in these children with emerging autism will inform targets for behavioural interventions in autism and language delay.

Impairments in social-communication skills are among the most important features of autism, although there is a great deal of variability in the severity of these difficulties. Communication skills (across receptive and expressive semantic, morphologic, syntactic and pragmatic domains) are extremely heterogeneous in individuals with autism, ranging from failure to develop any functional speech to the development of functional but idiosyncratic spoken language (Wetherby, 2008). Of particular relevance to this study is the marked impairment of prelinguistic intentional communication skills – specifically, limited joint attention skills and gesture use – that forms perhaps the earliest and clearest indicators for autism (Charman & Stone, 2006). Prelinguistic intentional communication refers to skills used during the stages prior to the emergence of spoken language, during which time communication appears to be intentional and directed toward communication partners, but has yet to take the form of speech (i.e., spoken words or word approximations). Watt, Wetherby and Shumway (2006) demonstrated that prelinguistic intentional communication behaviours – such as the production of conventional gestures (e.g., pointing), as well as the initiation of and engagement in joint attention – predicted subsequent rates of spoken language acquisition in typically developing infants.

The relationship between intentional communication and later language ability is important for both theoretical and clinical reasons. Theoretically, such an association provides information about the process of early language development (Bruner & Sherwood, 1983). Clinically, identifying characteristics and behaviours that are present in early development – prior to the onset of spoken language, and that are predictive of later language – enables the earlier identification of children at risk for language delay, before their difficulties become entrenched (McCathren et al., 2000) and when there is perhaps the greatest potential for support and intervention. Many theories have been posited and progressed regarding the role of prelinguistic intentional communication skills for subsequent language ability (Yoder et al., 2015) and these can be categorised as child-driven or transactional. Child-driven models focus on within-child factors. For example, Bruner and Sherwood (1983) postulated that gesture use and early vocalisations serve the same pragmatic functions (such as requesting and commenting) as do early words or spoken language (Bates & Dick, 2002; Bruner & Sherwood, 1983). Others have suggested that prelinguistic intentional communication skills and the emergence of language are related, as they rely on the same underlying cognitive processes (Bates & Dick, 2002; Golinkoff, 1986; Thal & Bates, 1988). Finally, another explanation for the relationship between prelinguistic intentional communication and later language ability is the transactional model. Yoder and Warren (1999) posited that intentional communication may be related to later language partially due to the fact that intentional communication elicits a response from a caregiver, which in turn facilitates later language development (e.g., through word labelling).

Although there is consensus that early identification and intervention are important in modifying subsequent language delay in children with autism, relatively little is known about the early development of prelinguistic intentional communication skills in autism as diagnosis rarely occurs before age 2 years. Converging lines of evidence indicate that general deficits, as well as specific precursors to some symptoms – such as language deficits – are present early on in autism (Elsabbagh & Johnson, 2010). This demonstrates the importance of investigation into precursors to language delay in children with autism. To date, much of the literature on prelinguistic intentional communication and subsequent language ability in children with autism tends to rely on two types of research design – retrospective reports/review of home video footage and prospective high-risk infant sibling studies (i.e., following the development of younger siblings of children with autism who have a 20% likelihood of developing autism; Ozonoff et al., 2011). While prospective studies improve upon retrospective designs by actively tracking child development as it unfolds, thereby reducing the influence of potential sources of bias (e.g., selection, recall), evolving research suggests that the developmental profiles of siblings of children with autism may be different to those of children identified from the general community as showing early signs of autism. That is, findings from high-risk infant sibling studies may not be representative of, or generalisable to, all of autism (Sacrey et al., 2017). Furthermore, the literature investigating language abilities in young children with autism, or in the context of emerging autism, has utilised different language measures across studies, making it difficult to draw direct comparisons and confident inferences across individual studies.

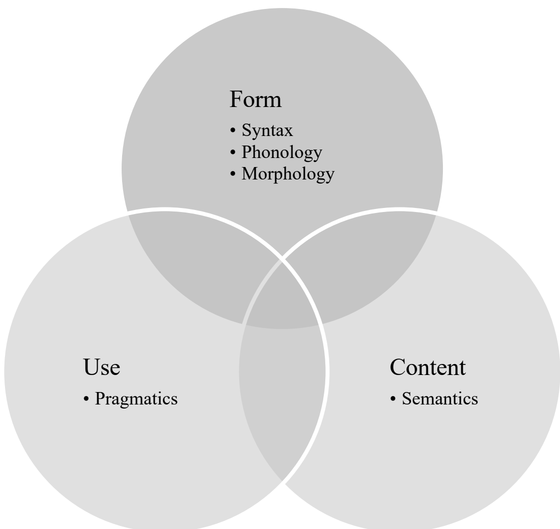
The remainder of this chapter presents a literature review outlining the importance of language and early prelinguistic intentional communication for typically developing children, and what is known in the context of children with autism. It begins with a discussion of prelinguistic intentional communication in the literature of both typical development and autism, and as relevant to subsequent language outcomes, following which a brief overview of the gaps in the literature to date is presented. A rationale for the current study is then provided, followed by a discussion of the study aims and hypotheses. Chapter 2 then considers broader methodological issues as relevant to this study and outlines the specific procedure and design of the research conducted here, and an overview of the study participants and description of the measures used. Chapter 3 reports findings relating to the study hypotheses, and Chapter 4 provides a discussion, reiterating the study results and linking these findings to the existing literature. Chapter 4 also considers the design strengths and limitations of this study and provides suggestions for future research.

Language in Early Childhood

Language is the systematic and conventional use of sounds (or signs or written symbols) for the purpose of communication or self-expression (Crystal, 1995). According to Bloom and Lahey (1978), there are a number of distinctions between components and subcomponents of language (see Figure 1). Bloom and Lahey described three separate but overlapping components of language: *form, content* and *use. Form* refers to the surface features of language and how these are arranged according to the grammar of the language. It incorporates morphology, syntax and phonology. *Content* refers to the topics and ideas that are encoded in linguistic messages (whether these are transmitted through sign language, writing or speech). And *use* refers to the reasons why people communicate – the function of language.

Figure 1

Components of language



As shown in Table 1, the subcomponents of *form* are syntax, phonology and morphology. *Content* consists of semantics and pragmatics falls under the component of *use.*

Table 1

Components and subcomponents of language

Component	Subcomponent	Definition
Form	Syntax	Rule system governing the order and combination of words to form sentences, and the relationships among the elements within a sentence
	Phonology	The use of individual sound units in a language and the rules by which they are combined and recombined to create larger language units
	Morphology	The rule system that governs the structure of words and the construction of word forms from the basic elements of meaning
Content	Semantics	The meaning of individual words as well as the meaning that is produced by a combination of words
Use	Pragmatics	Pragmatics consists of three major communication skills: 1) *Using language* for different purposes, such as greeting (e.g., hello, goodbye), informing (e.g., I'm going to get a biscuit), and requesting (e.g., I would like a biscuit); 2) *Changing language* according to the needs of a listener or situation, such as talking differently to a baby than to an adult; and 3) *Following rules* for conversations and storytelling, such as taking turns in conversation and how to use verbal and nonverbal signals.

Language in Typical Development

Language is important for all children as it assists with communication of feelings and needs, with parents, educators, physicians and other children. The first three years of a child's life, when the brain is rapidly developing and maturing, is the most intensive period for speech and language growth (Charman & Stone, 2006). Typically, children develop receptive language – the ability to *understand* the meaning of what others communicate including through words and sentences – before their development of expressive language – the ability to *produce* words by putting thoughts and sentences together in a way that makes sense and effectively communicates these ideas to others (Luyster et al., 2008).

In typical development, infants develop speech production quite rapidly. Infants begin babbling at around 6-months of age, and language comprehension emerges around 9-months of age. First words follow at around 12-months (Fenson et al., 1994), by which time infants are able to understand many more words and also some short phrases (Tager-Flusberg et al., 2009). Infants only produce phrases of their own later, usually between 18- and 24-months of age (Fenson et al., 1994) and typically developing children are able to speak in complete sentences by 3 years (Charman & Stone, 2006). Furthermore, typically developing children use language for social reasons to initiate and share conversation and social interactions with others (Wetherby, 1986). Children use language in social situations in a number of ways, such as for greeting or informing people about things, as well as having the ability to follow 'unspoken' rules of conversation, such as taking turns and using appropriate facial expressions. These kinds of skills are important as they enable children to build meaningful relationships with others and help with further language development through the opportunity to ask questions and the motivation to engage with others.

Language in Autism

Although deficits in language skills are an important feature of autism, research suggests that for young children with autism, abilities may range from being entirely nonverbal to being fluent, but with highly idiosyncratic use of language, including features such as echolalia (Ellis Weismer et al., 2010). This heterogeneity is further complicated by the fact that some children with autism exhibit adequate structural language skills – such as articulation/phonology, vocabulary/semantics, and grammar/morphology and syntax – but may have difficulty with prosody and abstract use of language (McCann & Peppé, 2003). The prosodic features of the speech produced by persons with autism are almost always odd, often sounding mechanical (Fay, 1993). Sometimes the speech produced by individuals with autism is also different in terms of pitch, volume, and voice quality (Lord & Paul, 1997; Tager-Flusberg, 1999).

As outlined above, typically developing children use language for various social reasons, whereas children with autism may use words most often to *regulate* their environment (such as to request or protest; Tager-Flusberg, Paul, & Lord, 2013). Although some children with autism have accompanying speech disorders (such as apraxia or oral-motor impairments) that may impair intelligibility, it is the absence or restriction of *communicative intent* that is characteristic of autism (Happé & Frith, 1996). For this reason, reduced motivation to engage in social-communication and emerging language acquisition difficulties may be mutually reinforcing.

There are a number of reported communication phenotypes of children with autism. The first is a language profile whereby receptive language skills are more impaired than expressive language skills (Barbaro & Dissanayake, 2012; Charman, Drew, et al., 2003; Kover et al., 2013; Luyster et al., 2008; Pickles et al., 2014;

Volden et al., 2011; Ellis Weismer et al., 2010). Additionally, some children with autism have also shown a regression (or loss) in social communication and/or language around two years of age (Baird et al., 2008; Barger et al., 2013; Lord et al., 2004; Ozonoff et al., 2005) or stereotypical language including echolalia, incessant questioning, pronoun reversal, and/or perseverative speech (Boucher, 2012; Tager-Flusberg, 2006). Finally, greater use of unusual vocalisations in infants with autism (Paul et al., 2011), abnormal prosody and vocal quality (Shriberg et al., 2001; Tager-Flusberg & Caronna, 2007) have been noted in autism.

Delays and deficits in language acquisition appear to be among the clearest early indicators of emerging autism (De Giacomo & Fombonne, 1998), with the absence of first words often representing the primary initial caregiver concern about the development of their child (Wetherby et al., 2004). Research in children with autism has suggested that receptive language can lag behind the level expected on the basis of the child's expressive language (Hudry et al., 2014; Kwok et al., 2015; Luyster et al., 2008), and this too may reflect reduced or different social motivation (Coster et al., 1999). A receptive language impairment may be often interpreted by parents or health professionals as a sign of issues related to hearing, however, children with autism may often ignore voices in their environment but be responsive to other non-vocal stimuli suggesting reduced social interest rather than a hearing difficulty (Klin, 1991). Children with autism tend to have limited language ability, with their ability often closely linked to broader cognitive abilities and attention skills (Mody & Belliveau, 2013).

Language Disorders and Overlap with Autism

The reported prevalence of language disorders in school-age children ranges from 5 to 8 per cent (Boyle et al., 1996). Severe speech and language disorders in young children can negatively affect later educational achievement, even after intensive intervention (Stern et al., 1995). Atypical language development can be a secondary characteristic of other physical and developmental problems that may first manifest in language. Conditions that can account for speech and language problems in children can be divided into primary speech and language problems, in which no other aetiology can be found, and secondary speech and language problems, which are attributable to another condition. Primary speech and language problems include development speech and language delay, expressive language disorder and receptive language disorder, amongst others. Secondary speech and language problems have been associated with autism, cerebral palsy, intellectual disabilities and hearing loss (McLaughlin, 2011).

Secondary speech and language problems are common to many neurodevelopmental disabilities and there is substantial overlap in features for young children with autism, language disorder/delay and developmental delay (Kjelgaard & Tager-Flusberg, 2001; Paul et al., 2008; Ellis Weismer et al., 2010). However, a notable distinction between autism and other developmental disabilities is that social communication difficulties are central to autism whereas in other developmental delays and language delays/disorders, social communication difficulties tend to be secondary, or consequential to language problems (Rice et al., 2005). Demouy et al. (2011) investigated the language profiles of children with SLI and autism in 12 children with autism and 13 children with SLI. Children from these groups were equivalent across age, sex and academic skills. One finding of this study was a unique speech prosody feature (rhythm, stress, intonation) feature amongst children with autism of rising intonation, which was not seen in the children with SLI.

Implications of Delayed Language

For children with autism, improvements in communicative skills have been shown to be closely related to the reduction of challenging behaviour (Kevan, 2003). Furthermore, studies of children with autism have shown that early language has implications for later social and adaptive functioning (Anderson et al., 2007; Luyster et al., 2008; McDuffie et al., 2005). A systematic review conducted by Magiati et al. (2014) investigated outcomes for adolescents and adults with autism in follow-up studies. Five of the eight studies in which language and/or early pre-communication factors were explored as possible predictors of adult outcomes demonstrated a consistent such effect, including for later-life adaptive behaviours and social outcomes.

Delays in language acquisition have also been linked to long-term impacts on wellbeing and mental health outcomes in adults with autism (Gillespie-Lynch et al., 2012). In a study conducted by Howlin et al. (2004) investigating childhood language ability and autism severity on adult outcomes, the majority of adult participants were rated as having a ‘Poor’ outcome – defined as requiring a high level of support, with no friends outside of residence – or a ‘Very Poor’ outcome – defined as requiring high-level hospital care, with no friends and no autonomy. This demonstrates a direct impact of childhood language ability on adult functioning outcomes in children with autism.

Prelinguistic Intentional Communication

Prelinguistic Intentional Communication in Typical Development

The developmental phase during which prelinguistic intentional communication emerges refers to the time between birth and when a child begins to use spoken words and sentences meaningfully (typically around 18-months of age). During this prelinguistic phase, infants progressively develop intentional and symbolic forms of communication representing a range of communicative and social functions. Intentional communication is defined as a triadic exchange, involving a shared focus between two individuals (Adamson et al., 2009, 2017; Bakeman & Adamson, 1984), in which the child's gestures, posture, vocalisations, gaze, and facial expressions demonstrate coordinated attention to an object, person or event (Volterra et al., 1979). Prelinguistic intentional communication skills are often considered as being the foundation on which many other communication and social skills are built.

Prelinguistic intentional communication can be characterised in terms of pragmatic function. *Imperative* acts describe occurrences where a child requests an object that is out of reach or requests an action *with* an object and is a form of communication with the purpose of meeting an immediate need or desire (i.e., behaviour regulation; Gomez, Sarria, & Tamarit, 1993). Other types of communicative acts may be intended to share attention or to engage with a social partner and these are called *declarative* acts; acts serving to share awareness or experiences with others (Mundy, 1995) rather than to achieve a particular instrumental end. That is, declarative acts have a more *social motive* than imperative or instrumental acts (Gomez et al., 1993; Tomasello, 1995).

Prelinguistic Intentional Communication in Autism

Limited prelinguistic intentional communication is considered to be a core deficit in the communication profile of children with autism (Noens & Berckelaer-Onnes, 2005; Travis & Sigman, 2001; Wetherby et al., 2000), and differences in social-communication skills between children with and without autism are particularly evident and unique in the preverbal stage (Mundy & Crowson, 1997;

Travis & Sigman, 2001). Identifying prelinguistic predictors of language outcomes contributes to conceptualising models of language development by elucidating the relative importance of the underpinnings of language. In addition, identifying these predictors is essential for improving early identification of children who may be at risk for poor language outcomes (Wetherby et al., 2004). Individual differences in a number of prelinguistic skills in the second year have been found to predict later language skills. For example, research, such as by Fenson et al. (1994) has shown the importance of early vocalisations and words in the development of later expressive language. Play is another prelinguistic skills which has been shown to be predictive of language outcomes as it provides a context for language learning (Bopp & Mirenda, 2011). There is robust evidence to show that two social communication skills identified as being crucial for subsequent language abilities are *gesture use* and *joint attention.* Specifically, children with autism are less likely than typically developing children to use symbolic gestures – like showing or pointing out objects of interest. Rather, children with autism predominately use physical cues – such as pushing or directing another's hand to an object of interest – to convey their desires (Mastrogiuseppe et al., 2015; Stone et al., 2007). Researchers have focused on the role of social-communication in infancy for the development of language acquisition in early childhood, finding early social-communicative skills to be precursors to the development of key language milestones in children with autism (Luyster et al., 2008) just as in typical development.

In children with autism, prelinguistic intentional communication may be used less often, in fewer types of circumstances, and with less flexibility or ease (McDuffie et al., 2005). Children with autism exhibit a specific pattern of prelinguistic intentional communication that is predominantly imperative and is used primarily to regulate another’s behaviour (Landa et al., 2013), such as acquiring an object that is out of reach or directing the activity of another person, instead of initiating instances of declarative prelinguistic intentional communication (i.e., solely for the purpose of sharing). Conversely, typically developing children and children with other developmental delays or disabilities, such as Down syndrome, express a wide range of functional communication and intents early in development (Shulman et al., 2001). Previous research reveals that children with autism often request, protest, and greet intentionally, but use few gestures of pointing or showing to label or comment intentionally and often express a limited repertoire of communicative intents (Wetherby & Prutting, 1984). Despite variability in levels of language development and cognitive ability, children with autism often exhibit a relatively homogeneous profile of communicative intents distinct from that of children without autism (Tomasello et al., 2007). Disproportions in imperatives and declaratives between children with autism and typically developing children/children with other developmental disabilities, highlights the importance of continued investigation into prelinguistic intentional communication in children with autism and in infants in whom autism may be emerging.

Prelinguistic Intentional Communication Characteristics

Joint Attention. Episodes of eye gaze and joint attention – the shared focus of two individuals on a given object or event – provide children with a great deal of information about their environment by establishing reference and intention, and a context that enables the child to associate meaning with a particular utterance (Woodward, 2005). Consequently, joint attention deficits may result in a cascade of missed language-learning opportunities as part of building vocabulary through object-word associations. In typical development, one important operationalisation of joint attention is the ability of infants to follow a shift of gaze and/or the head turn of an adult (Adamson et al., 2017); an ability that emerges between 6- to 12-months of age and consolidates across the infancy/toddlerhood period until around two years of age (Butterworth & Morissette, 1996; Carpenter et al., 1998).

Joint attention is described as the triadic coordination (or sharing) of attention with another person, and then with an object or event (Leekam & Ramsden, 2006). In typically developing infants, there is a predictable developmental trajectory of joint attention skill over the first 2 years of life. From as early as 6-months of age to the end of the first year of life, infants develop joint attention skills (Bakeman & Adamson, 1984) including both the capacity for response to joint attention (RJA) and initiation of joint attention (IJA). That is, RJA is a child's ability to shift attention to follow a social partner's gaze or pointing gesture, when the partner is the initiator of the joint attention act. IJA, by contrast, is the child's ability to instigate the sharing of attention by coordinating his or her gaze between an object, or event, with gaze toward a social partner (Bottema-Beutel, 2016). Children develop other communication skills, and language, *in combination with* joint attention, which then enhances their further understanding and use of language (Sameroff & Fiese, 2000). Engaging with objects and with social partners in a coordinated way is critical for infants' developing understanding of others' thoughts, feelings and goals (Klin, Jones, Schultz, Volkmar, & Cohen, 2002; Tomasello et al., 2007). Therefore, the development of both RJA and IJA skills represent major milestones for all children, with or without disability.

Lack of coordinated gaze between an infant, adult and object/event, which involves the use of joint attention (e.g., Morales et al., 2000), is among one of the earliest indicators of autism (Werner & Dawson, 2005), discriminating between children with and without a diagnosis (Shumway & Wetherby, 2009), and prospectively predicting autism symptoms even into adulthood (Gillespie-Lynch et al., 2012). Shumway and Wetherby (2009) studied the communicative profiles of 125 children aged between 18- and 24-months of age (50 of which were later diagnosed with autism, 25 with developmental delay and 50 with typical development). Measurement of rate, function, and means of communication were obtained through systematic observation of videotaped behaviours samples that were elicited in accordance with the Communication and Symbolic Behavior Scales Developmental Profile. It was found that children with autism communicated at a significantly lower rate than both children with development delay and those following typical development. Of importance to this study was that children with autism were shown to use a significantly lower proportion of acts of joint attention and gestures compared with children with developmental delay or typical development.

In typical development, RJA and IJA have been demonstrated to develop simultaneously – whereby children contemporaneously learn to *initiate* joint attention with others whilst also *responding* when others initiate joint attention with them (Salley et al., 2016) – in autism, children show a developmental divergence (Charman & Stone, 2006). Children with autism often first learn to coordinate their attention between a person and an object in the context of communication *imperatives* – that is, when requesting something that they want, using joint attention behaviours for instrumental function – rather than in the context of communication *declaratives*, for the purpose of sharing interests or for other social interaction functions. This functional distinction has been demonstrated by Dawson et al. (2004) who found that joint attention skills discriminated children with autism from children with developmental delay or typical development, correctly classifying 83% of children with and 63% of children without autism.

As a form of prelinguistic intentional communication, joint attention has been shown to be a pertinent predictor of both receptive and expressive language in children with autism, even beyond the value of other known predictors of language, such as parent linguistic input. Yoder et al. (2015), in a longitudinal study of 87 children with autism who were initially non-verbal (when recruited at age 24- to 48-months), found that joint attention significantly predicted receptive and expressive language growth. In addition to research investigating early language abilities and adult outcomes, this finding provides further evidence of the importance of joint attention in predicting subsequent language ability in children with autism. The finding is also consistent with those of many studies that have demonstrated longitudinal associations between joint attention abilities, including following eye gaze and pointing, and language learning and later language ability in typically developing infants (Mundy & Gomes, 1998; Tomasello & Farrar, 1986; Volterra et al., 1979). In another longitudinal study of the predictive value of early joint attention skills, Morales et al. (2000), used the Early Social Communication Scales (ESCS) to assess joint attention skills in 22 infants at 2-monthly intervals beginning at 8-months of age. Findings indicated that individual differences in early response to joint attention skills were significantly related to language outcomes on the MCDI at age 2-years.

Gestures Use. The development of gesture use demonstrates a notable transition in the growth of intentional communication capacity as gestures provide a clear means for establishing reference compared with other more ambiguous means of communication, such as use of eye gaze or facial expressions. Gestures such as holding out items to give or show them, reaching to request, and pointing to indicate an item of interest are the first gestures to emerge in typical development (Volterra et al., 1979). Gestures are important for children as they learn to effectively communicate with others. That is, before children are able to use spoken language, gestures enable children to effectively communicate with others in their environment, such as through pointing to indicate joint reference, and waving in greeting (Crais, Watson, & Baranek, 2009).

Between 6 and 10 months of age, typically developing children begin to use gestures communicatively with others, such as reaching to indicate their desire to be picked up or obtain an object, or pushing away objects that they do not want (Carpenter et al., 1998; Crais et al., 2009; Parladé & Iverson, 2015). Gestures are defined as actions used with the intent to communicate and are usually expressed using the fingers, hands, and arms, but can also include body motions to describe or enact ideas (e.g., bouncing to describe the movement of a "horsey"; Iverson & Thal, 1998). In contrast, simply reaching or grabbing for something is not considered communicative unless the child is using that action to signal to someone else what their intention is.

Iverson and Thal (1998) categorised two primary types of gestures: deictic and representational. Deictic gestures call attention to or indicate an object or event, such as pointing to or holding up an object to show someone. As suggested by Iverson and Thal, these gestures are interpreted according to the context and can be used across a range of objects and events. Deictic gestures are frequently divided into two types: contact and distal (Brady et al., 2004). Contact gestures include touching the object or another person, such as pulling on an object held by another or pushing away a caregiver's hand; they are considered to be early gestures, appearing between 7 and 9 months. In contrast, distal gestures do not require contact with the caregiver or the object and include pointing or waving “bye bye” and typically appear later than contact gestures (10-12 months).

Representational gestures indicate both reference and a particular semantic content. Iverson and Thal (1998) categorized representational gestures into object-related and conventional gestures. Object-related gestures denote some feature of the referent (e.g., flapping the arms to represent a bird flying) and are considered to be symbolic forms (Mundy et al., 1987). They are considered to be conventional according to common use and understanding within a particular culture (e.g., waving “bye”, finger to lips for “quiet” in western cultures). They typically represent some action or concept rather than a specific object.

Iverson and Goldin-Meadow (2005) have postulated that gestures allow typically developing children to communicate ideas and wants for which they may not yet have the words or verbal capacity. Hence, the use of gestures may be facilitative of language learning. Gestures can also assist children in indicating objects of interest to caregivers, which in turn may lead to object labelling by the caregiver and provide an opportunity for children to learn new words (Goldin-Meadow et al., 2007). This also then enables children to prompt input from their caregivers, soliciting information that they need to further their own language learning and development. Research has also suggested that referencing or commenting by a child (e.g., pointing to an object to show it) has a strong connection with receptive language development (Colonnesi et al., 2010). When children reference an object through pointing or other gestures, caregivers usually respond by labelling the object or providing additional information to the child (Brady et al., 2004, 2013; Tomasello & Farrar, 1986). Thus, children who gesture more often will have increased chances to gain input from caregivers and subsequently bolster their language learning opportunities (Reilly et al., 2009).

Returning to the situation of children with autism, the majority of research to date suggests that children with autism produce fewer gestures on average compared with typically developing children and other clinical comparison groups (e.g., Pedersen, 1997; Winder, Wozniak, Parladé, & Iverson, 2013) and that their gesture range is less diverse than that of their non-autistic peers (Colgan et al., 2006; Winder et al., 2013). Similarly to the use of joint attention, children with autism are more likely to use gestures imperatively – that is, to regulate others' behaviour, such as pointing to have someone provide them with something – rather than for the purpose of social interaction, such as pointing declaratively to comment on something interesting (e.g., waving "hi", or "bye bye", or nodding or shaking head "yes" or "no"; Ramos-Cabo et al., 2019).

Why Prelinguistic Intentional Communication is Important

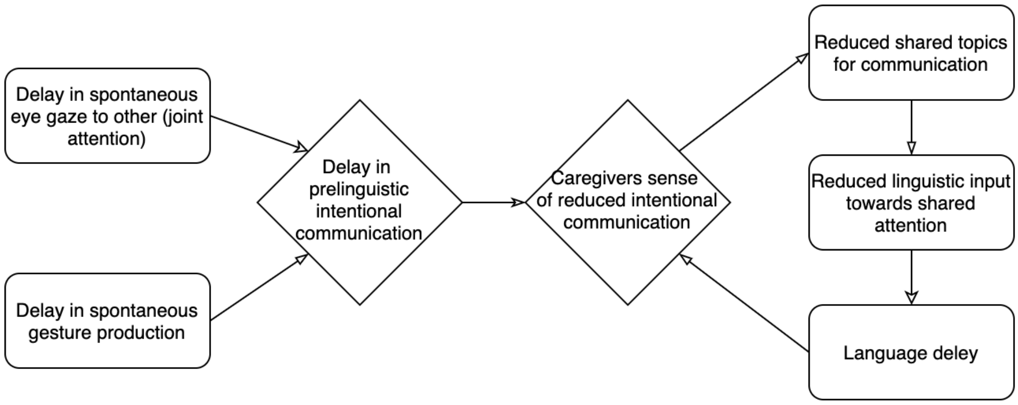
The prelinguistic stage of intentional communication builds the basis for later developing skills – such as learning new words and combining those words into sentences that can be used to communicate – as well as skills needed for understanding the complex and diverse distinctions of social-communication. For all children, the skills learned during this prelinguistic stage can be critical to the development of effective and successful communication throughout late-childhood, and adolescence and adulthood. A shift to intentional communication is critical to the development of language and higher-level and nuanced social-communication (Brady et al., 2004; Tomasello et al., 2007). A child's adeptness in prelinguistic intentional communication has been shown to be predictive of later language outcomes (Donnellan et al., 2020). Furthermore, higher rates of early nonverbal intentional communication are related to improved language outcomes (Sandbank et al., 2017). In a study conducted by Calandrella and Wilcox (2000), 25 children with developmental delay (aged 17- to 38- months) were observed during natural interactions with their primary caregiver at 6-month intervals over a 12-month period. Researchers were interested in the relationship between prelinguistic abilities and later receptive and expressive language outcomes. They found that nonverbal communication (that included coordinated attention or was *intentional*) was associated with better subsequent language outcomes.

Successful communication is bi-directional and requires an exchange and reciprocity between those who are communicating. A visual representation of the cascading effects of early communicative delays on language development is presented below in Figure 2. As communication and social deficits are both key features of autism, consideration of not only what language skills are acquired, but how those skills are used and developed during social interactions is important. Research in typical development has examined how communication exchanges around a unified purpose develop, which can be used as a useful point of comparison for studying minimally verbal children.

As described above, infants between the ages of 6- and 12-months begin to share their attention on objects and events with communication partners, moving toward triadic joint engagement (De Schuymer et al., 2011; Mundy et al., 2009). A significant skill that develops through triadic engagement is the ability to follow others' gaze, which opens up opportunities for the infant to learn from other people about the environment around them, thereby leading to more opportunities for word learning (Rozga et al., 2011). When this kind of exchange is compromised (i.e., because one of the communication partners initiates communication and shared attention only infrequently; such as in the context of childhood autism), this is likely to impact the quantity and quality of input available (Arunachalam & Luyster, 2018). If a child with autism is initiating fewer communicative activities, their social partner has fewer opportunities to provide a response. Reduced opportunities for caregivers and other adults to respond could therefore negatively impact the development of these skills for children with autism (Bishop, 2014).

Figure 2

Cascading effects of early communicative delays on language development



When a caregiver responds to an episode of joint attention that is initiated by a child, they often provide input on something that is salient and motivating to the child's current focus of attention (e.g., Goldin-Meadow et al., 2007). Instances such as these are critical for word and language learning as the child's attention is focused on an object of interest and the caregiver is able to directly label that object for the child. Work with typically developing infants indicates that children are more likely to learn new words under these conditions (i.e., when they are motivated and attentive to an object) than when a label is provided for an object to which they are not already directly attending (Tomasello & Farrar, 1986). Siller and Sigman (2008) have provided evidence of a similar underlying process in children with autism. In this study, Siller and Sigman conducted four waves of data collection with 22 boys and 6 girls (with a mean age of 45.2 months and a language age of 36 months or less) using the Reynell Developmental Language Scales, the MSEL and the Childhood Evaluation of Language Fundamentals – Revised to measure language. Joint engagement was measured using the Early Social Communication Scale and videotaped mother-child interactions. The findings showed that children's rate of language growth was independently predicted by (a) children's responsiveness to others' bids for joint attention and (b) parents' responsiveness to their children's attention during play. Both predictive relations could not be explained by initial variation in global developmental characteristics, such as IQ, mental age, or language abilities. Similarly, in a study of 55 minimally verbal children with autism, DiStefano et al. (2016) found that children's participation in communication interchanges (unbroken back-and-forth exchanges around a unified purpose) at mean age 6.5 years was positively associated with spoken language gains over a 6-month period.

Prelinguistic Intentional Communication Deficits and Later Language Skills

As demonstrated above, a child's ability and proficiency to use prelinguistic intentional communication may play a crucial role in their successful transition to spoken language and later language competency. This has been established in the robust research literature base, whereby prelinguistic intentional communication skills have been shown to be concurrently associated with a range of skills in both typical development (Goldstein et al., 2010; Watson et al., 2013) and autism (Anderson et al., 2007; Mundy et al., 1987; Tomasello & Farrar, 1986). In one such study of children with autism, Poon et al. (2012) showed that the mean level of social communication behaviours (joint attention, imitation and object play as observed in home video recordings) at 9-12 months, and not the rate of change in these behaviours over time, predicted communication scores on the Vineland Adaptive Behavior Scales at 3-7 years of age. This has also been demonstrated prospectively, with early joint attention skills shown to be highly predictive of subsequent receptive and expressive language in both typically developing children (Slaughter & McConnell, 2003) and children with autism (Charman, 2003). In this latter study conducted by Charman (2003), concurrent and longitudinal associations between joint attention and other social communication abilities were measured in a sample of infants with autism at age 20-months, and language abilities at 42 months. Early joint attention abilities were shown to be positively associated with later language abilities.

Similarly, early gesture use has been found to be strongly associated with concurrent receptive language in both children with typical language skills (Volterra et al., 1979) and those with language deficits (Thal & Bates, 1988). Further, Rowe and colleagues (Rowe et al., 2008; Rowe & Goldin-Meadow, 2009) have shown gesture use at 18-months of age in typically developing children to be significantly related to subsequent receptive language at 4 years of age. Again, in children following typical development (*n*=52) observed interacting with their caregivers at home, Rowe and Goldin-Meadow (2009) found that gesture use at 18-months selectively predicted lexical versus syntactic skills at 42-months, even with early child speech controlled. Moreover, frequency of requesting and commenting have also been shown to be predictive of later spoken language (McDuffie et al., 2005; Mundy et al., 1987; Sigman & Ruskin, 1999; Stone et al., 1997).

Gestures, such as communicative pointing (distal), not only enable joint attention episodes with others, but also impact upon what communication partners look at and subsequently comment on – furthering the potential for language learning. Not only does the emergence of gestures facilitate effective communication for infants and young children, but this also has a potential impact on the language-learning environment. Gaze, joint attention and gesture use provide caregivers and other adults with clear, noticeable, and specific cues as to the child's current focus of interest, enabling them to capitalise on the child's engagement and motivation and providing a spoken response and or opportunity to label an object. These opportunities can therefore provide ample opportunities for word learning as the child is already focused on the object, creating an environment primed for the acquisition of new words (e.g., Tomasello & Farrar, 1986; Leekam & Ramsden, 2006).

Methodological Approaches to Studying Prelinguistic Intentional Communication Deficits

Retrospective Design

In order to better understand the relationship between prelinguistic intentional communication and language in the context of autism, there is recognition that this association must be studied in infancy, when prelinguistic intentional communication skills are emerging. Naturally, this is before the development of language itself is expected and also before the time of confirmed autism diagnosis, when early behaviours are emerging and consolidating. There have been a number of approaches taken and methodologies explored to investigate early development in the context of autism. One example of this is through the use of a retrospective methodology. Thorough work with retrospective parent-report and the review of home videos of young children with autism has consistently shown impairments in prelinguistic intentional communication skills in the first years of life among those later diagnosed with autism (Barbaro & Dissanayake, 2009; Yirmiya & Charman, 2010). For example, in a study of videotaped first birthday parties, Osterling and Dawson (1994) reported that infants later diagnosed with autism had shown social deficits in eye gaze, affect, and in the joint attention behaviours of showing and pointing. Similarly, Bernabei et al. (1998) found that while pointing and showing were rare behaviours, following another's gaze (gaze monitoring) was altogether absent in the home video footage of children later diagnosed with autism, during the first 18-months of life.

Retrospective designs provided important early insights into the prelinguistic intentional communication deficits presenting in infancy, among children subsequently diagnosed with autism. However, there are a number of limitations to research based on the retrospective analysis of home video footage, and associated research based on retrospective parent-report, including lack of standardisation in behaviour sampling and the potential for recall and other reporting biases (i.e., parental knowledge of the child's eventual diagnosis). Similarly, revisions to the diagnostic criteria of autism according to both the American Psychological Association (APA; 1994, 2000, and 2013) and the International Classification of Disease (ICD; 1979 and 1999) systems have meant that contemporary definitions of autism have changed since the time when research based on retrospective study design was published.

Prospective Infant Sibling Design

To overcome challenges posed by a reliance on retrospective study design, researchers have more recently leveraged the potential from prospective longitudinal studies to seek insights into the development of infants in whom autism is emerging.

Specifically, research over more than a decade has tracked the development of infants at familial high risk for autism. Infant siblings of children with autism are at known elevated risk for autism (and other developmental delays, including language impairment; Constantino et al., 2010; Messinger et al., 2013; Ozonoff et al., 2011), and readily identifiable early in life, facilitating recruitment into research whereby development can be tracked prospectively and longitudinally, using objective measurement. By comparing prospectively collected data from high-risk infants who later do vs do not meet diagnostic criteria for autism, researchers are able to identify early markers of later autism diagnosis. Findings from studies utilising this methodological approach have demonstrated a clear link between reduced prelinguistic intentional communication skills and subsequent language development. Specifically, impairments in the use of declaratives – gestures and eye gaze produced for shared attention purposes – have been identified among high-risk infant siblings, at 14- to 19-months of age (Goldberg et al., 2005) and 12- to 23-months of age (Stone et al., 1997), showing lower motivation to initiate instances of declarative intentional communication with others.

Although high-risk infant sibling studies show promise for examining the early features of autism – such as investigating prelinguistic intentional communication and language prospectively during key periods of development – potential considerations regarding bias and generalisability of cases have also been raised, which the field is only just beginning to consider (Sacrey et al., 2017). Specifically, high-risk infant sibling samples comprise children who have grown up in an environment already affected by autism. Children with autism from multiplex families – where there is more than one individual with an autism diagnosis – have higher cognitive function and adaptive skills than do simplex cases – families where only one child has autism (Pandey, 2007).

Furthermore, factors such as the potentially earlier recognition of symptoms, engagement with intervention services, and differential parenting styles and parental stress (Zwaigenbaum et al., 2007) may systematically differentiate the early experience of infants born into a family where there is already a child with autism, leading to further issues with generalisability of findings from studies of autism in infant siblings. Potential biases of these types, from studies of emerging autism restricted to samples of high-risk infant siblings, may be mitigated through the recruitment of infants in whom autism is emerging identified via community-referral.

Community-Referral Design

An alternative approach to studying the early development of autism, prospectively as it emerges, is to identify infants who are themselves showing emerging symptoms via clinical/community-referral pathways. Given the evidence demonstrating that high-risk infant siblings may not be representative of *all* children with autism (Sacrey et al., 2017), due to their inherent multiplex status and potentially altered rearing environment as a result of the presence of the older, already-diagnosed sibling, a community-ascertainment approach to recruitment of infants with emerging autism has the potential to further elucidate the relationship between prelinguistic intentional communication and subsequent language ability that is generalisable to the population of interest. In one of the only studies to date investigating developmental profiles in infants with *emerging* autism identified through a community-based setting, Barbaro & Dissanayake (2012) found infants with emerging autism to have poorer receptive and expressive language abilities compared with children with developmental or language delay. To the best of our knowledge, there have been no studies to date examining the prelinguistic intentional communication skills and associated language development of infants with possible emerging autism identified through community care pathways.

Rationale, Aims and Hypotheses

This literature review has highlighted how prelinguistic intentional communication skills are important in the context of childhood autism, as well as in the context of language development. For children with autism in the prelinguistic stage, the acquisition of joint attention skills and gesture use is critical to concurrent and subsequent development of language and social communication skills. The majority of research to date has examined prelinguistic intentional communication retrospectively in children with an existing diagnosis of autism, or prospectively in the specific context of high-risk infant sibling studies. However, little research has examined the predictive value of prelinguistic intentional communication abilities among infants in whom autism may be emerging – beyond the specific context of high-risk infant sibling studies – during the developmental period when these skills should be emerging and have key relevance to language development (i.e., 12- to 24-months). Additionally, few studies have examined language abilities in children with autism or with emerging autism utilising varied language measures to observe consistency/convergence in the pattern of findings obtained, and none have yet done so in a community referred sample of infants with possible emerging autism. The current research fills this gap by investigating the predictive value of two types of prelinguistic intentional communication skills – joint attention and gesture use – for developing language, in a unique cohort of infants with possible emerging autism, identified on the basis of presenting early behavioural signs of autism via community-referral.

This research was conducted in the context of a larger prospective, longitudinal study whereby infants were recruited from the community on the basis of showing early behavioural signs of autism. Data for this study was taken from two timepoints, when the children were aged around 12-months (hereafter, *baseline*) and 24-months of age (hereafter, *follow-up*), and include baseline measures of prelinguistic intentional communication skills (i.e., joint attention and gesture use) and language measures across two approaches (i.e., parent-report and direct assessment) at both baseline and follow-up assessments.

The specific study aims were: 1) to profile the early prelinguistic intentional communication abilities – that is, joint attention skills and gesture use; 2) to profile the receptive and expressive language abilities of infants with possible emerging autism, and the continuity of these skills over time; and 3) to evaluate the predictive value of the earlier prelinguistic intentional communication skills for subsequent language development across the one-year follow-up period. Specifically, it was hypothesised that the infants':

1. Receptive and expressive language skills would be reduced, relative to chronological age, across both measures, at baseline and follow-up;
2. Receptive and expressive language scores, within and between scales, would be correlated across the assessment measures taken concurrently, suggesting convergent measurement validity, and prospectively, suggesting predictive validity and continuity of skills;

3. Early joint attention skills and gesture use would be associated with concurrent measures of receptive and expressive language (i.e., at baseline assessment);
4. Early joint attention skills and gesture use would be associated with prospective measures of receptive and expressive language (i.e., at follow-up assessment);
5. Level of autism symptoms measured at baseline would be associated with key study measures taken concurrently – that is, baseline measures of joint attention skills, gesture use and receptive and expressive language – and potentially also prospectively associated with the key language measures taken at follow-up assessment;
6. Early joint attention skills and gesture use (i.e., at baseline) would be predictive of later language ability (i.e., at follow-up), controlling for autism symptoms and baseline levels of receptive/expressive language skill.

Chapter 2: Methods

In this Chapter, broader methodological considerations pertinent to this study are reviewed – including broad aspects of study design and measurement – followed by the presentation of specific details of the larger study which provided the dataset for the empirical work reported in this study.

Methodological Considerations for Studying Early Language Development

Prospective Longitudinal Design

As previously argued, in order to understand the significance of prelinguistic skills on subsequent language development in young children with autism we must look at associations between measures of these factors over time, as they are developing, and *prior to* the typical age of autism diagnosis (very rarely ocurring before the age of two years). In recent years, prospective longitudinal design – research that employs continuous or repeated measures to follow children over time – has become a useful means of analysing communication skills in infants with emerging autism. A prospective longitudinal design allows researchers to recruit infants early in development and track them over time, taking measurements at multiple timepoints as they grow older. This design was chosen in preference to retrospective designs of children with established autism (which relies on approaches such as parent-report or the review of family home video footage, both of which are difficult to standardise), or a reliance on cross-sectional designs which may include multiple measures for analysis but is limited in the extent to which inferences about developmental processes and causal relations can be determined. Prospective studies are not subject to recall bias, can be designed to examine precise constructs, and can provide multiple data collection timepoints and measurement comparability across individual children over time. This study design also allows the collection of data longitudinally across different ages, which can promote our understanding of developmental trajectories and the impact of early delays in one domain (e.g., prelinguistic intentional communication) on the subsequent development in another (e.g., language).

There exist a number of different recruitment methods for identifying a suitable sample for prospective longitudinal analysis. As outlined in Chapter 1, the most notable approach adopted over the last two decades has been the high-risk infant sibling design, founded on research showing that the recurrence rate of autism among siblings is around 18% (Ozonoff et al., 2011). Being the younger sibling of a child with autism is one of the most clearly defined 'high-risk' groups available. Hence, the main strength of the high-risk infant sibling research design is in the ability to directly identify infants in whom there is a high likelihood of diagnostic outcome, and to do so early in life allowing the study of emerging autism from far earlier than would be possible by relying on recruitment at the time of diagnosis. Furthermore, infants can then be followed prospectively and longitudinally from infancy allowing for true developmental tracking. However, recent research has suggested that constraining focus to the unique group that high risk infant siblings represent may not necessarily yeild outcomes that generalise to the wider population of children developing autism (Sacrey et al., 2017).

Studying the development of children with emerging autism who are identified from the general community – on the basis of showing early signs of autism in infancy – is a promising alternative prospective approach that is not solely oriented towards the recruitment of infant siblings. One such approach to identify infants through community referral from routine 'community primary care' providers, which ensures infants enrolled in research are ascertained based on the presentation of emerging symptoms rather than their eligibility being based on the diagnosis of an older sibling. Like the high-risk infant sibling design, this approach affords the potential to study the emergence of autism prospectively and longitudinally as it occurs, prior to the age of a formal diagnosis, with the benefit of better reflecting the larger population of children with autism for whom research inferences are intended to apply.

To date, very few studies have evaluated the early development of children with autism identified through community referral pathways. One of these, the local Australian Social Attention and Communication Study (SACS; Barbaro & Dissanayake, 2010), aimed to identify infants and toddlers at risk of developing autism during their first 2 years of life by training Maternal and Child Health nurses to monitor the development of key social-communication behaviours, such as use of eye contact and response to name. Another similar example is research from the United States, which concerns the development and evaluation of the First-Year Inventory (FYI; Turner-Brown et al., 2013), a community-identification method producing a cohort from which researchers can evaluate the early development of infants with possible emerging autism who are not solely born into multiplex autism families. Although not focused on autism, a large prospective community-based study of almost 2,000 children in Victoria, Australia (the Early Language in Victoria Study; ELVS) provides an example of a large longitudinal study of child language impairment (Reilly et al., 2009). Participants were followed up at 8-months, 12-months and 24-months. ELVS has enabled embedded research relating to early communication skill development in children who were later diagnosed with autism. Finally, the Modified Checklist for Autism in Toddlers (M-CHAT) is a 23-item yes/no parent report checklist and can be used in both high- and low-risk populations (Charman et al., 2016).

Research on typically-developing children, as well as research on children with developmental disorders, indicates that there are ‘critical periods’ for the development of skills that are commonly delayed or absent in autism; for example, between the ages of 6- and 18-months when social-communicative behaviours such as joint attention skills, pointing, and gesture use are typically consolidated (Adamson et al., 2017). Multiple assessments within such critical periods have the potential to be extremely informative about the timing and developmental sequence and consequences of delays.

Where assessing behaviours of interest as they emerge in infancy necessitates their evaluation prior to the determination of children’s diagnostic outcome, studies have utilised continuous measures of the extent of emerging autism symptoms as a way to examine the co-emergence of developmental difference and autism risk. The inclusion of continuous measures of autism symptom presentation is important given that decisive categorical diagnostic assessment cannot be confidently made until around child age 3 years (Pierce et al., 2009). The benefit of including a continuous measure allows quantification of the extent to which symptoms are emerging. Furthermore, accepting variability around a given mean participant age at recruitment and assessment timepoints avoids seeking to artificially and tightly control factors such as age and diagnostic outcome classification. Instead, these factors – age, symptom severity – may be varied but can then be factored into analyses, thereby informing developmental and symptom-related effects.

Prospective studies of infants identified through community-referral pathways with possible emerging autism may also be informative, therefore, in ascertaining associations between characteristics over time, rather than with a sole focus on categorical diagnostic outcome. This approach enables research to focus on skills and difficulties at multiple timepoints and ages through a child's development – potentially highlighting patterns concurrently (how abilities are associated with one another at a particular time point) and also prospectively (how they might predict later abilities and be associated over time) – and maximising all available participant engagement and data rather than constraining participation and valid data to specific age-limited timepoints or diagnostic outcome groupings. Furthermore, this approach lends itself to the possibility of identifying certain developmental trajectories that identify infants with consolidating autism symptoms – likely to lead to a subsequent diagnosis – or in infants whose apparent early emerging autism symptoms might dissipate (or canalise) over time. Where prospective, longitudinal studies of emerging autism usually rely on diagnostic outcome classification (i.e., waiting for infants to be old enough to separate those with and without autism, and then comparing their skills and/or difficulties from assessments earlier in life), this approach permits the analysis of skills and difficulties as data are collected, and as a function of continuous measures of autism symptoms.

Given the potential usefulness of a community-referral approach for informing early development in infants with emerging autism to an extent that is likely generalisable to the broader population, it is important also to consider any potential limitations to this approach. Firstly, and as already discussed, most prospective research focuses on diagnostic outcome classification, requiring investigators to wait for the cohort to reach the point of diagnostic outcome (rarely prior to the age of 3 years at which point stability of autism diagnosis increases significantly; Kleinman et al., 2008). However, a straightforward solution is to shift focus to the emergence and development of skills as a function of the extent of autism symptom emergence measured *continuously*. A second possible limitation is loss of participants to follow-up – inevitable in longitudinal research but with a number of viable options for mitigation. For example, participants with missing data may simply be omitted from a given analysis (i.e., pairwise deletion) or removed completely (i.e., listwise deletion) during the analysis process. Checks on the similarity of subgroups excluded/retained from analysis can inform the extent to which any bias might be present in the subgroup lost to follow-up and interpretation adjusted accordingly.

Any prospective, longitudinal research with community-referred infants also brings the disadvantage of infant attention span constraining the number of possible measures included in the assessment battery. It is not possible to conduct lengthy assessments with infants due to fatigue, so assessment batteries must necessarily be streamlined in order to minimise missing data. Hence, it may not be possible to comprehensively measure all potential variables of interest, with measures prioritised to align with broader study priorities. Finally, while community referral study design has the potential to better inform knowledge on the development of children with autism through more representative sampling of affected infants and young children, the recruitment challenges utilising this method – including the training of community care practitioners, participant engagement at recruitment and for ongoing retention, and the reality of potential anxiety and stigma for parents (Marlow et al., 2019) – mean that achieving sizeable samples is potentially difficult.

Measuring Early Language Skills

Additional methodological considerations are specifically related to the measurement of language skills in the context of emerging autism. Although researchers agree on the importance of adequately appraising language competence among young children with autism, the potentially very low level of receptive and expressive language skills in this group – or in infants in whom autism may be emerging – presents several challenges. A number of potential strategies have been examined in the literature to date as a means of ensuring the precise and useful measurement of language development in infants and children with autism.

One approach to accurately and consistently measure language in children or infants with autism over time is through direct standardised assessment. There exist a wide range of standardised language assessments for use with children. These include the Bayley Scales of Infant and Toddler Development (Bayley-III; Bayley, 2006), the New Reynell Development Language Scale (NRDLS; Edwards et al., 2011), and items from the Mullen Scales of Early Learning (MSEL; Mullen, 1995). Choices from the various options, for the current study, were made on the basis of key requirements for the study and consideration of strategies used in the research literature. One of these, the MSEL is an assessment of developmental functioning suitable for children from birth to 5 years 8 months and includes receptive and expressive language domains. The MSEL Receptive Language domain assesses children's ability to understand language, for example, as an examiner asks them to identify a particular object (e.g., "where is the door?") and follow simple verbal commands (e.g., "put it in the box"). The MSEL Expressive Language domain assesses a child's word production, for example, as an examiner asks them to label objects (e.g., "what is this?"), answer basic knowledge questions (e.g., "how old are you?"), and repeat sentences verbatim (e.g., "I like to ride in the car"). Children receive item-level scores between 0 and 3 depending on their demonstration of various skills, following which, standardised norm-referenced t-scores, percentile ranks, and age equivalence scores can be computed for each scale.

Standardised direct assessments of language ability have the advantage of being based on formal observations of behaviour evidencing a child's understanding of and ability to produce language under conditions elicited by highly trained personnel, often with extensive education and understanding of child language development. Furthermore, assessment procedures are standardised so that each child is tested in a highly similar fashion. Psychometric testing has indicated measures such as the MSEL to have good reliability (including returning similar scores when a given child is assessed by different examiners) and validity (in producing scores similar to when a child is assessed on other comparable assessments), and norming data take into consideration natural skill variation as a function of child age and sex.

There are a number of further advantages, but also potential disadvantages however, to the use of standardised direct assessment to quantify the language skills of young children with autism. For example, the use of standardised testing is an advantage in research on language development in children with autism given that language abilities are heterogenous in this group (irrespective of chronological age) and so standardised age equivalence scores – where a child's performance on a test is ascertained as comparable to the average level of children of a given age – can be an important derived metric for understanding the language development of infants and children with emerging autism. Furthermore, these norm reference scores take into account the typical variation in language ability by sex (i.e., accounting for boys being generally more delayed than girls); an important distinction given that the ratio of male-to-female children meeting criteria for autism is around three to one (Loomes et al., 2017) and with boys therefore often overrepresented in the autism research literature. For this reason, comparison of child abilities to standardised assessment scores that account for sex differences are useful for language development research in autism.

Nevertheless, lack of motivation (Koegel et al., 1997), short attention span, and problems of cooperation with examiners (Feldman et al., 2005) may influence the performance of children with autism on standardized testing, such as during administration of the MSEL. Compliance and performance problems are more prevalent among younger typically developing children (Shula & Penny, 2007), and further compounded in the case of young children with autism (Charman, 2004). For example, it can be hard to judge the degree of comprehension of many children with autism because of their reluctance or lack of motivation to orient to social cues. Otherwise stated, children with autism have demonstrated difficulties with attention control which, in combination with reduced social motivation, may lead to issues with accurate measurement of language ability. Standardised direct assessment scores for young children with autism also tend often to fall below instrument basal levels – that is, the minimum criterion of performance against which all preceding items are assumed to be passed – and therefore may not accurately represent the true extent of a given child's difficulties (Charman, 2003; Luyster et al., 2008). This knowledge has led researchers to propose that the direct formal assessment of language may be less appropriate for young children with autism compared with typically developing children with whom such assessments have been developed in the first instance (Charman, 2004; Tager-Flusberg et al., 2009).

Another approach often used in measuring language development in infants and children with autism is via parent-report. For example, parent observations may be recorded on the basis of their opportunity to observe their children in everyday settings in order to supplement or even replace the direct assessment of language ability in young children with autism (e.g., Drew et al., 2002; Stone & Yoder, 2001). There are a number of parent-report assessments available which include the Communication and Symbolic Behavior Scale (CSBS; Wetherby & Prizant, 2002), the Ages and Stages Questionnaire (ASQ; Squires et al., 1999) and the MacArthur-Bates Communicative Development Inventory (MCDI; Fenson et al., 1994).

As above, choices from the various parent-report options, for the current study, were made on the basis of key requirements for the study and consideration of strategies used in the research literature. The MCDI, for example, comprises several forms, with the appropriate one selected depending on the child's age and language ability. For example, the 'Words and Gestures' form is suitable for children whose language is between the normative range of children aged 8- to 16-months, while the 'Words and Sentences' form is designed for children whose language is between the normative ranges of 16- to 30-months (i.e., girls with more than 30 words and boys with more than 40 words). By way of further example, the MCDI 'Words and Gestures' form – assessing a child's early communication abilities – includes measures of gesture use, as well as inventories for vocabulary comprehension and vocabulary production. The latter two scores are compiled based on a vocabulary 'count' completed by the parent, indicating the sum of the number of words a child *understands* and is able to both *understand* and *say* from a list of approximately 400 words commonly acquired early in childhood. These raw vocabulary count scores can then be converted into norm-referenced percentile ranks or age equivalence scores. In the standardisation sample, the average number of words produced for girls was higher than for boys at 16-months of age, so norm-referenced scores were created by child sex as well as age (again, an important consideration in autism research given the over-representation of boys in most cohorts).

Despite potential advantages of parental report of language development, there are also potential disadvantages. One is the potential for parental overreporting – particularly with regards to child vocabulary comprehension – where contextual understanding of gestures and familiar routines by the child may be mistaken for true language comprehension by his or her parent (e.g., believing the child understands "let's go", when the child is really responding to his or her parent picking up keys). This confounding of comprehension of language compared with contextual cues may be particularly the case when in the context of routines that are well-rehearsed (Tomasello & Mervis, 1994).

Given the known impact of early language abilities on functional prognosis in adulthood in autism (Howlin et al., 2004; Tager-Flusberg et al., 2009), it is particularly important that child language assessment be comprehensive, reliable, and valid, as well as developmentally appropriate (Volden et al., 2011). Given that approaches such as those proposed above present both advantages and disadvantages when used with young children with autism, a sensible strategy may be to combine measures of language from more than one source in order to more accurately and comprehensively measure language abilities and development in this cohort. For example, the combination of information from a parent-report source – such as the MCDI – with scores from a direct, standardised test – such as the MSEL – may provide a more solid global assessment (Sparrow et al., 1984). This could be gained through the combination of information gained from standardised testing procedures and also the increased opportunities for skill demonstration in a familiar environment from parent report measures.

Available Indicators of Prelinguistic Intentional Communication Skills

As discussed in Chapter 1, assessing prelinguistic intentional communication early in development (i.e., before the emergence of spoken language) is important both theoretically, to inform our understanding of the impact of early prelinguistic intentional communication on language development, and clinically, to support social-communication development in infants with emerging autism. However, compared with the comprehensive and well-researched measures that exist for assessing language development, there are a host of challenges facing researchers and clinicians seeking to examine prelinguistic intentional communication skills, ranging from choice of assessment to issues related to selecting appropriate measures.

Measuring social communication behaviours is difficult due to potential inconsistencies in the interaction environment, the social partner, characteristics of the individual child, information source (e.g., parent-report or direct assessment), and the properties of the assessment tool itself (Parladé & Iverson, 2015; Watt et al., 2006). As with language measurement, approaches to measuring prelinguistic skills vary from standardised to non-standardised approaches, include examiner-administered and parent-report methods, and may be derived from longitudinal or cross-sectional study designs. Studies focused on measuring prelinguistic intentional communication in infants have included direct-administered standardised assessments such as the Communication and Symbolic Behavior Scales-Developmental Profile (Wetherby & Prizant, 2002) and the Early Social Communication Scales (Mundy et al., 2003). These assessments typically include stimuli such as exciting toys or activities (e.g., a wind-up toy, an intentionally deflating balloon, activating an animated toy) that the examiner uses to engage the child for the purpose of measuring joint attention skills (Kasari et al., 1990). As with standardised language assessments, the advantages of examiner-administered standardised assessments of prelinguistic intentional communication skills include the controlled protocol which standardise the type and number of opportunities for communication provided to the child, and the standardisation sample of previously assessed children against whom a given child's scores can be measured. Standardised measurement also alleviates other sources of variability – such as those inherent in parent-report methods – that may impact upon the consistency of results.

However, the limitations of standardised assessment for the measurement of prelinguistic intentional communication skills may include dampened child performance in the context of unfamiliarity of examiner and testing environment; such that a young child might be reticent to display skills they truly have (Fuchs et al., 1985). Again, another approach to the assessment of prelinguistic intentional communication skills includes caregiver report measures such as the aforementioned 'Actions and Gestures' subscale of the MCDI (Fenson et al., 2007). As already discussed, the benefits of using parent-report measures of prelinguistic intentional communication skills include the potential to gather a more representative assessment of a child's skills, as parents spend more time with the child, are familiar to the child, and provide a familiar environment.

A further benefit of parent-report method is ease of use. Standardised assessments of prelinguistic intentional communication skills are less likely to be incorporated within infant assessment batteries, or included routinely in large developmental studies, compared for example with standardised and comprehensive measures of language which are routinely included, such as embedded within broader developmental/cognitive assessments. In infant studies, research teams must necessarily be selective about the amount of data collection that is feasible with infant participants, and the specific measures included, with selection of tools for maximal gain. Whereas language ability is a valued measure (with direct assessment and parent-report options being reliable, valid and routinely available including within broader developmental skills assessments), prelinguistic intentional communication measures may be less feasibly incorporated within study protocols, or only in parent-report format.

Where standardised assessments of prelinguistic intentional communication are not feasibly included within infant assessment batteries, researchers may nevertheless extract relevant data from within other measures. This is particularly the case where clinical or behavioural phenotyping concerning emerging autism is concerned and indicators of prelinguistic intentional communication feature as items within scales tapping other higher-level constructs, such as communication skill or emergent symptom presentation. For example, items tapping prelinguistic intentional communication skills are included among codes within the Social Attention and Communication-Revised (SACS-R); a checklist of early risk markers for autism that can be used by clinicians at 12-month well-child checks to identify children whose behaviour may be indicative of early autism (Barbaro & Dissanayake, 2010). One particular SACS-R item requires the health professional to gain the child's attention and then point across the room, showing interest and excitement; thereby providing a measure of child response to joint attention as it requires the child to look to the object, rather than just looking at the health professional's arm or elsewhere.

Another example of a measure that includes assessment of prelinguistic intentional communication skills is the Autism Observational Scale for Infants (AOSI; Bryson et al., 2008)– a brief semi-structured, experimenter-led assessment of emerging signs of autism. Here, an item measuring infant capacity for shared interest, requires the examiner to rate the infant's use of gaze to reference and share interest in an object or event with another person (i.e., the examiner, or caregiver) within the 15- to 20-minute assessment. The child's behaviour is then coded according to whether he or she 'spontaneously shifts gaze to share interest in an object or event', demonstrates 'questionable social referencing' or makes 'no clear example of social referencing'. This kind of secondary data can be useful in efficiently measuring prelinguistic intentional communication.

The challenge in employing only one measurement method – parent-report or direct rating of observed behaviour – may be that children differ in which prelinguistic skills they use (and how frequently) across settings/interaction contexts. Therefore, the benefit of drawing data from items assessing prelinguistic intentional communication skills across other measures commonly-incorporated within infant study batteries (e.g., AOSI, SACS-R) is that – similar to the strategy for language measurement – this leverages the strengths of utilising multiple methods for gaining information about children's prelinguistic intentional communicative behaviours (Crais et al., 2009; Tager-Flusberg et al., 2009).

Design and Procedure for the Current Study

Presented above was a review of the methodology relevant to this study, including broad considerations of study design and measurement for the field. The remainder of this chapter concerns specific methodological details pertinent to the current study research.

The current data were drawn from a larger study investigating the early development of infants with emerging autism identified through community referral pathways (Whitehouse et al., 2019). The study was approved by the Child and

Adolescent Health Service Ethics Committee (2016008EP) with reciprocal approval by the La Trobe University Human Ethics Committee, and each parent provided written informed consent for their infant's participation. Participants were referred to the study through community primary care providers and were eligible if they demonstrated 3 out of 5 key items on the SACS-R 12-month checklist (atypical/absent pointing, waving, imitation, eye contact, response to name; Barbaro & Dissanayake, 2010). This checklist has an estimated >70% positive predictive value for early childhood autism diagnosis (Whitehouse et al., 2019). Exclusion criteria included infant gestational age below 32 weeks and/or major medical complications or illness. Participants were initially recruited at mean age 12-months and followed up at mean age 24-months. At each of baseline and follow-up visit, families attended the laboratory for a direct assessment that lasted 2 to 3 hours. Assessments were conducted by Honours-level psychology research assistants who had experience with infants and young children with autism. Assessments consisted of multiple measures of language and social-communication skills, including via direct assessment and parent-report, used here for analysis of language abilities, prelinguistic intentional communication skills and autism symptoms. Scales were coded according to author guidelines.

Key Measures for the Current Study

Language Ability

Direct Assessment of Receptive and Expressive Language Skills. Participants were administered the Mullen Scales of Early Learning (MSEL; Mullen, 1995). As outlined above, this is a standardised developmental assessment suitable for children from birth to 68 months, which provides raw scores, as well as norm-referenced subscale standardised and age equivalence scores, including for receptive and expressive language domains as part of an overall developmental assessment. MSEL assessment data were available for each child at each of the baseline and follow-up assessments. The MSEL manual (Mullen, 1995) reports satisfactory to good internal consistency (Cronbach's a=0.75 to 0.83), satisfactory to excellent test-retest reliability (r=0.71 to 0.96), and excellent inter-rater reliability (r=0.91 to 0.99). The receptive and expressive MSEL scales have also demonstrated good convergent validity with other language scales (rs ranging between .72 and .85; Mullen, 1995). For this study, raw receptive and expressive language scale scores were used for key analyses, rather than standardised scores, to be consistent with existing literature (Charman et al., 2001; Luyster et al., 2008) and to better capture individual differences in skills over time, and in light of the potential for floor effects on standardised scores. Age equivalence scores were computed and reported to facilitate interpretability of the data.

Parent-Report of Receptive and Expressive Language Skills. The MacArthur-Bates Communicative Development Inventories (MCDI; Fenson et al., 2007), also outlined above, provides a parental assessment of a child's early language. The MCDI is suitable for use with children whose language skills fall within the normative levels of children aged 8- to 16-months ('Words and Gestures' form) or 16- to 30-months ('Words and Sentences' form), providing measures of vocabulary comprehension and vocabulary production. Parents in the current study completed the MCDI 'Words and Gestures' form at baseline and the MCDI 'Words and Sentences' form at follow-up. Assessment norms have been developed on a wide range of children and the MCDI has been found to have excellent reliability and validity for both typical and autistic populations. The MCDI receptive and expressive scales have demonstrated good internal consistency (Cronbach's *a* values of .95 and .96 respectively) and test-retest reliability (*rs* above .8 for both scales; Fenson et al., 2007). The MCDI has also demonstrated moderate convergent validity against the Peabody Picture Vocabulary Test direct assessment of receptive vocabulary (PPVT, *r*=.67; Dunn & Dunn, 1997) and the receptive and expressive scales on the direct assessment Reynell Developmental Language Scales (RDLS, *r*s .82 and .59 respectively; Reynell & Gruber, 1990). Consistent with existing literature, analyses in this study used total receptive and expressive vocabulary counts (Charman et al., 2003; Luyster et al., 2008). As for the MSEL, age equivalence scores were computed and reported to facilitate interpretability of the data.

Prelinguistic Intentional Communication

No purpose-built assessment of infant prelinguistic intentional communication skills was included in the larger study protocol, and so indicators of joint attention and gesture use were derived from within other measures. The measures and indicators of prelinguistic intentional communication skills outlined below were all derived from baseline assessments.

Response to Joint Attention (RJA). As outlined above, the Social Attention and Communication Surveillance-Revised (SACS-R; Barbaro & Dissanayake, 2010) is a checklist administered by health professionals to identify infants showing early behavioural signs of autism and was used in the broader study as a recruitment and identification tool. One item on the SACS-R concerns child capacity for response to joint attention. To rate this item – 'Follows Point' – health professionals gain the child's attention and then point to an object across the room, showing enthusiasm. The child receives a rating of 'typical' RJA if they look to where the health professional is pointing (e.g., as opposed to just looking at their arm) and a rating of ‘atypical’ if the child did *not* orient to the object pointed at by the health practitioner. This single-item rating of typical (score of 1) and atypical (score of 2) RJA was reverse-coded for analysis so that children with higher scores demonstrated more typical RJA. Although there is no reliability or validity data for the individual SACS-R indicator for RJA given these have not been analysed as part of a standard protocol or commonly used assessment battery, the overall SACS-R tool has demonstrated good reliability and validity (Barbaro & Dissanayake, 2013).

Initiation of Joint Attention (IJA). The Autism Observation Scale for Infants (AOSI; Bryson et al., 2008) is a direct assessment to quantify signs of emerging autism in infants aged 6- to 18-months, commonly used in prospective research protocols such as studies tracking the development of high-risk infant siblings. The AOSI includes 21-items scored from direct observation by the examiner during the brief 15- to 20-minute interactive assessment. The item, ‘Shared engagement’ concerns child capacity for initiation of joint attention (IJA). This item is a rating of the child’s behaviour at any point during the AOSI assessment, capturing the examiner’s observations of the child’s ability to use their eyes to reference and share interest in an object or event with another person. The child receives a score of 0 if they spontaneously shift their gaze to share interest at least once during the assessment, a score of 1 if they demonstrate questionable social referencing, and a score of 2 if they do not demonstrate any example of social referencing. For the current analysis, and ease of interpretation, ratings were reverse-coded so that a score of 0 reflected ‘poor’, 1 reflected ‘fair’, and 2 reflected ‘good’ IJA. Analyses for the data collected as part of this study revealed good intra-rater reliability for this item (r=.75) and good inter-rater reliability (r=.71). Test-retest reliability for individual items has also been demonstrated to be within acceptable limits (.61 and .68; Bryson et al., 2008).

Gesture Use. As already outlined above, the MCDI (Fenson et al., 1994) is a measure of a child's early communication skills. Along with the vocabulary inventories described above, the MCDI 'Words and Gestures' form also includes an 'Actions and Gestures' subscale concerning child use of communicative and symbolic gestures. The first section, 'First Communicative Gestures', includes a set of items covering a variety of early gestures, including imperative, declarative and conventional gestures. Parents indicated next to each item whether their child was as yet demonstrating these behaviours on a scale of: "Not Yet", "Sometimes", and "Often". The number of items (out of 12) on the 'First Communicative Gesture' form endorsed by the parent was used as the measure of gesture use. Scores on each item were summed to create a gesture total score, with possible scores ranging from 0 to 12. Studies specifically concerning the overall 'Actions and Gestures' subscale of the MCDI have demonstrated good internal consistency (Cronbach's a=.88, Fenson et al., 2007), good test-retest reliability (rs $\geq$.80; Fenson et al., 2007), and has demonstrated good concurrent validity with experimental measures of gesture use (r's ranging from .43 to .62; Carpenter et al., 1998).

Autism Symptomology

Given interest in the role of autism in the relationship between prelinguistic intentional communication and language development for this study, and that children in the study had not yet reached the age at which diagnostic outcome classification could be determined, baseline assessment of autism symptom expression was included in analyses. Specifically, this was assessed using the AOSI as outlined above. Briefly again, the AOSI is a semi-structured, experimenter-led assessment of emerging autism-related behavioural markers in infancy (6- to 18-months). A standard set of objects and toys are used across five activities – each with a set of presses for a certain behaviour – and two periods of free-play. Child responses to presses made throughout the assessment are used to code 16 key items (separate to the additional 'Shared engagement' item utilised above for IJA), each item on a scale from 0 to 2 or 3 where a score of 0 indicates typical behaviour and higher scores indicate greater extent of autism symptoms. The AOSI Total score is the sum of these 16 key items, with higher total scores indicative of greater autism symptoms (maximum score 44). The AOSI has demonstrated good to excellent inter-rater reliability (*rs* ranging from .68 to .94) and good predictive validity against outcome measures of autism diagnosis (such as the Autism Diagnostic Observation Scale; Gotham et al., 2007), demonstrating specificity estimates of 86% (Bryson et al., 2008).

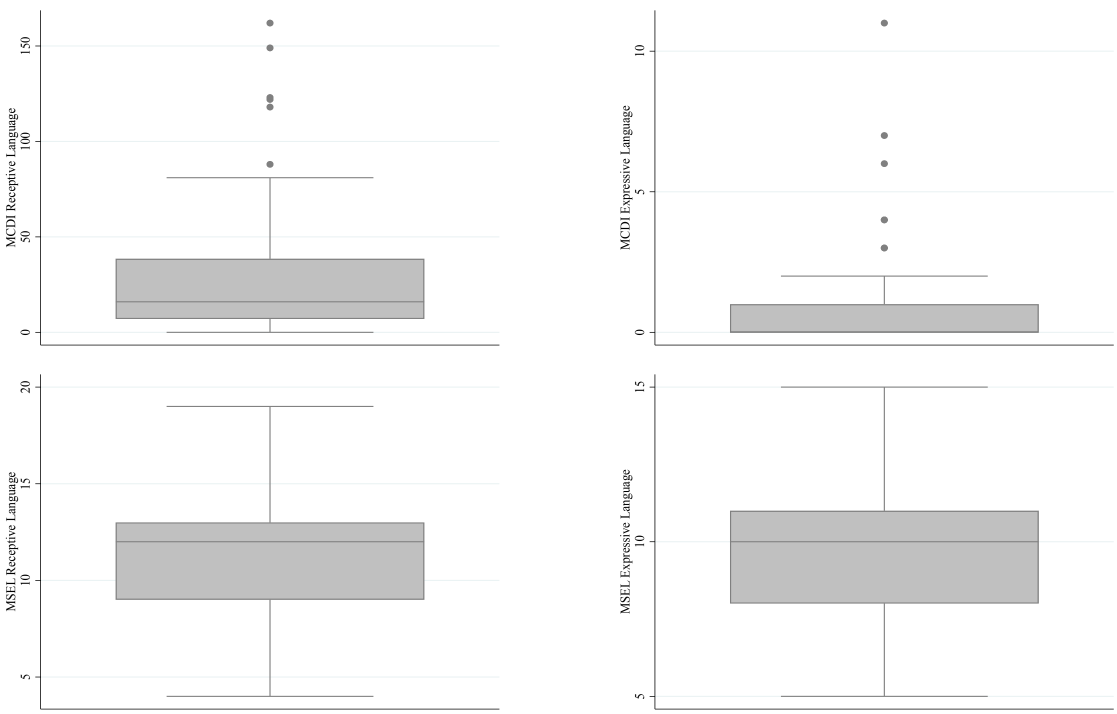
Preliminary Data Handling

Data for a cohort of 72 toddlers retained for the study were from assessment of their language abilities at both timepoints were screened for normality and for the presence of outliers. MSEL scores were normally distributed at baseline ($p>.05$). However, baseline MCDI scores were not normally distributed as assessed by the Shapiro-Wilks test ($p<.001$). At follow-up, neither the MCDI receptive or expressive language scales, nor the MSEL receptive language scale were normally distributed ($p<.01$). By contrast, scores on the MSEL expressive language scale were normally distributed ($p>.05$). A decision was made not to transform the data to preserve the true reflection of scores (Tabachnick & Fidell, 2007) and given that the sample size exceeded 50, it was deemed that there would be little likelihood of an impact on validity from the non-normal data (Pituch & Stevens, 2016).

As shown in Figure 3, at baseline assessment, statistical outlier cases presented on MCDI receptive and expressive language raw scores, with these instances representing different participants across the two domains. In an effort to minimise the influence of the MCDI outliers, winsorizing was conducted – a transformation method by which these extreme values were replaced with the values of the next nearest non-outlier data points (Ruppert, 2006).

Figure 3

Box plots showing spread of raw scores and outliers on receptive and expressive domains of the MacArthur-Bates Communicative Development Inventories (MCDI) and the Mullen Scales of Early Learning (MSEL) at baseline

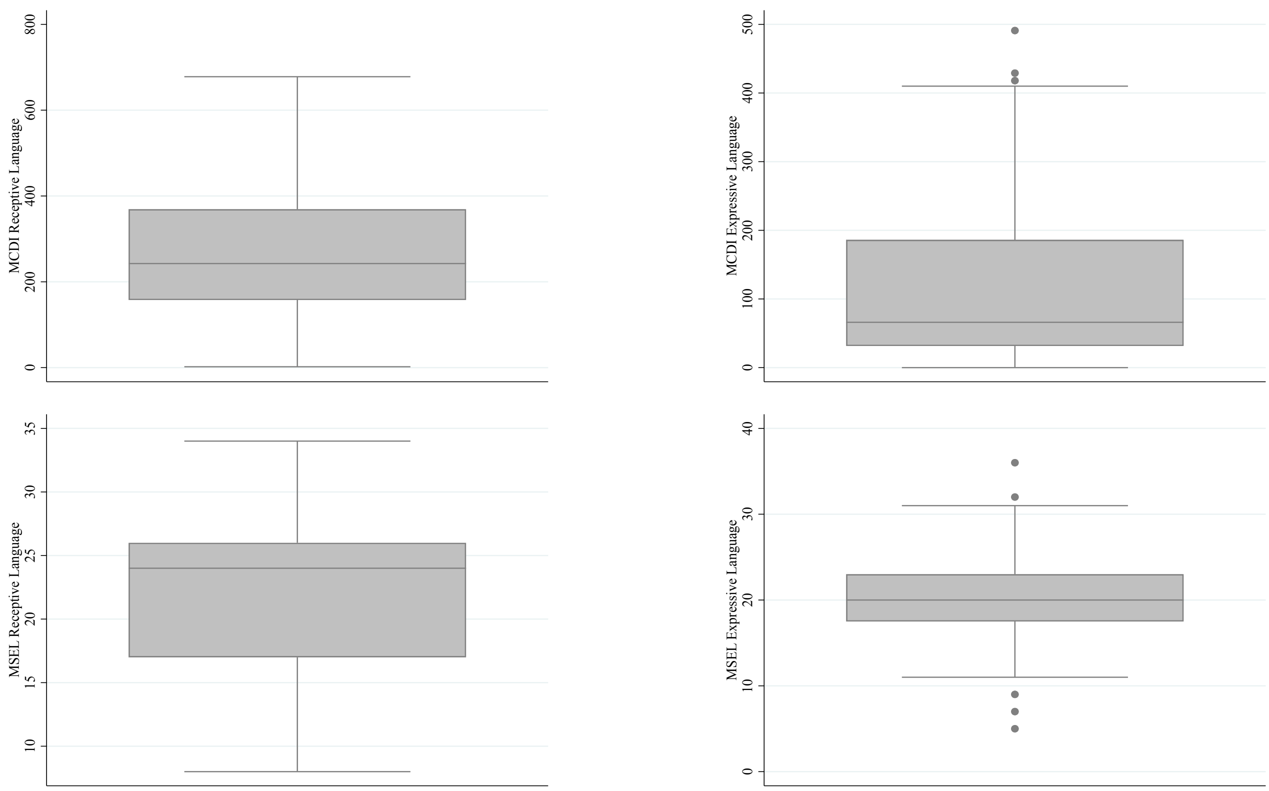


Note. N=72

As shown in Figure 4, at follow-up, statistical outlier cases were apparent on the expressive language domains of both the MCDI and the MSEL, but not on either measure of receptive language. These included three instances of high outlier datapoints on the MCDI and two instances (i.e., different children) of high outliers on the MSEL expressive scales. A further three instances of low outliers also presented on the MSEL. Again, winsorizing was conducted to minimise the influence of the MCDI and MSEL expressive language outlier datapoints.

Figure 4

Box plots showing spread of raw scores and outliers on receptive and expressive domains of MacArthur-Bates Communicative Development Inventories (MCDI) and the Mullen Scales of Early Learning (MSEL) at follow-up



Note. N=72

For the purposes of comparing language ability to chronological age, MSEL and MCDI raw scores were converted to age equivalence scores using the normative data provided with each instrument. For regression analyses, raw scores on the language measures were converted to z-scores to enable useful comparison between the measures. In order to include the IJA measure (a categorical variable with three levels) in the hierarchical linear regression analyses, this was recoded into two dichotomous variables – reflecting children with fair vs. poor, and good vs. poor IJA skill.

Statistical Analysis Plan

In order to test the proposed hypotheses concerning the relationship between prelinguistic intentional communication skills and language outcomes, descriptive statistics were computed to profile the prelinguistic intentional communication skills and early language abilities of this cohort of infants with emerging autism relative to chronological age and assessment normative data, and Pearson’s correlations were additionally computed to test the concurrent associations between language measures at each timepoint and the predictive associations of these from baseline to follow-up. A combination of Pearson’s correlations, chi-square tests, t-tests and ANOVAs were used to examine associations between the derived measures of baseline prelinguistic intentional communication skills (i.e., RJA, IJA and gesture use) and language skills at concurrent (i.e., baseline) and prospective (i.e., follow-up) assessment, as well as the relevance of a continuous measure of autism symptomatology to these key factors of interest. Finally, a series of hierarchical linear regressions were used to examine the relative predictive value of those indicators of baseline prelinguistic intentional communication skills and autism symptoms found to be significantly associated with language outcomes for each measure of receptive and expressive language outcome – controlling for baseline level of the given language ability. Hierarchical linear regression was chosen to enable examination of combined and unique predictive contributions. Four separate hierarchical regression analyses were conducted: one for each of the key language measures. Variables entered as predictors into each regression were those for which significant correlations with the outcome variable of interest had been identified, and these were entered in order to elucidate the added predictive value of the key variables of interest at each step. Stata Version 16 (StataCorp, 2019) was used for all analyses.

Chapter 3: Results

This chapter will begin with an outline of participant characterisation data, describing the demographic characteristics, including autism symptom presentation, of this cohort of infants identified with possible emerging autism via community referral. This chapter will then proceed to describe preliminary handling of the key data that was required before formal statistical testing of the study hypotheses. Analyses addressing each of the hypotheses are presented in turn.

Participant Characterisation

Of the 104 infants recruited into the larger study, 32 were excluded from further consideration for this study because full data on all variables pertinent to the study topic were not available. Hence, the results discussed here represent data for a total of 72 toddlers (69% of the recruited cohort). Specifically, four infants were excluded because they were missing data on either language measure at baseline, and 17 because of missing data on either language measure at follow-up. A further 11 infants were excluded as they were lost to follow-up assessment altogether. The infant participants in the final cohort ranged in age from 9- to 16-months, with a mean age of 11.72 months (SD=1.97) at the time of baseline testing, and at follow-up, from 21- to 30-months with a mean age of 24.63 months (SD=2.22). Males comprised 65.28% of the sample (i.e., 47 males, 25 females). A summary of participant characteristics at both baseline and follow-up is provided in Table 2. This includes available data for the 32 infants recruited into the larger study who were excluded from the current study, with no significant differences on broad characterisation measures apparent between those infants retained in the analysis sample and those infants excluded.

Table 2

Participant demographic characteristics at baseline and follow-up

	Baseline		
	Retained cohort (n=72)	Excluded cohort (n=32)	Between group comparison
Male *n* (%)	47 (65.28)	24 (75%)	χ^2=0.97, *p*=.967
	M (*SD*) Range	*M* (*SD*) Range	
Age (months)	11.72 (1.97) 9-16	12.28 (1.90) 9-15	*t*=1.35, *df*=102, *p*=.181, *d*=0.29
AOSI Total Score	8.79 (4.58) 1-28	9.25 (3.65) 3-18	*t*=0.50, *df*=102, *p*=.618, *d*=0.11
	Follow-up		
Age (months)	24.63 (2.22) 21-30	24.47 (2.18) 21-27	*t*=-0.27, *df*=91, *p*=.787, *d*=0.07

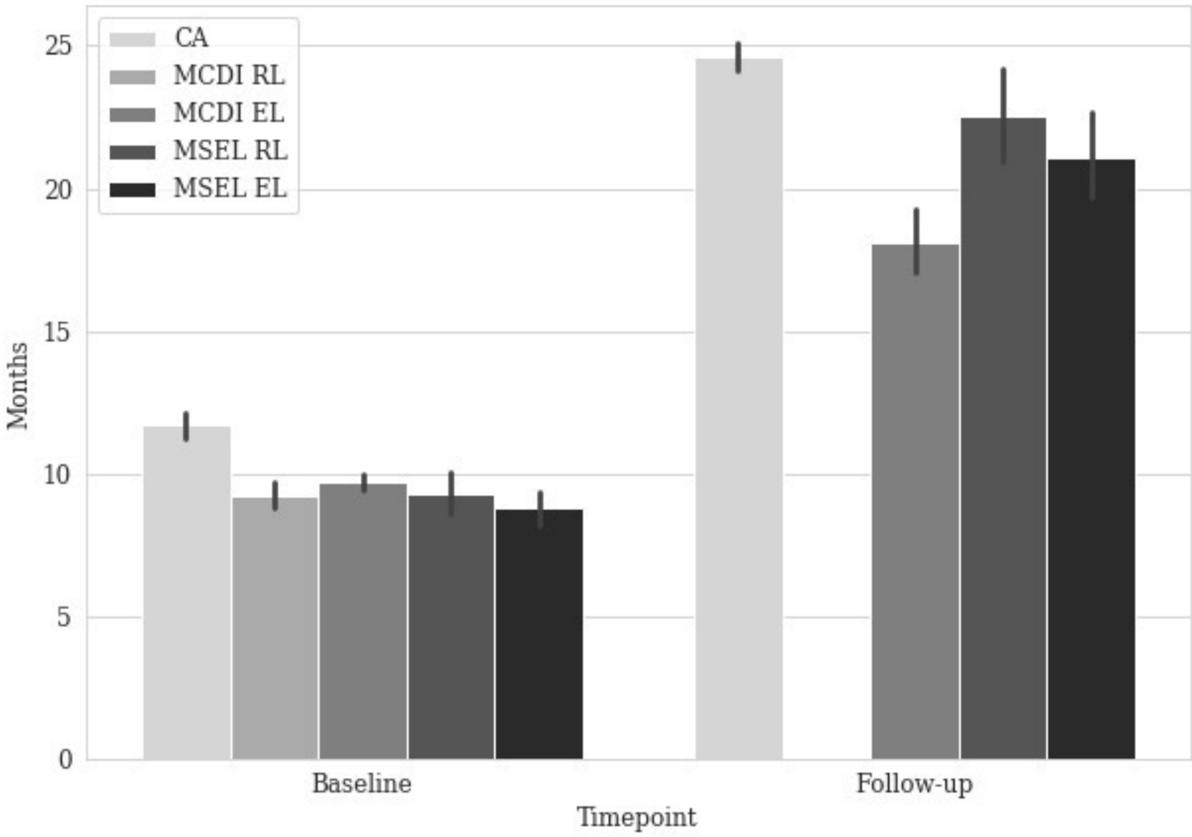
Note. AOSI = Autism Observation Scale for Infants.

Participant Language Skills

Descriptive statistics were computed to address Hypothesis 1; that the infants' receptive and expressive language skills would be reduced relative to chronological age across both the parent-report and direct assessment measures and at each of the baseline and follow-up assessment timepoints. Age equivalence scores were not able to be computed for the MCDI receptive language scale due to fitted percentile scores only being available up to 18-months of age for receptive language (Bryson et al., 2008). As shown in Figure 5, infants' receptive and expressive language age equivalence scores on the MSEL and their expressive language scores on the MCDI assessments were significantly reduced, relative to chronological age, at both baseline and follow-up assessments. On average, infants were 2- to 3-months delayed in their language abilities, and this was consistent at both time points and, as shown in Table 3, paired samples t-tests demonstrated that age equivalence scores on the MSEL and the MCDI at both timepoints were significantly different to chronological age. However, substantial variability was apparent. For example, individual infants' MSEL age equivalence scores ranged between 2- and 18- months and their MCDI scores between 8- and 15-months, at baseline, when chronological ages ranged between 9- and 16-months. Difference scores computed by subtracting each infants' chronological age by age equivalence indicated that while some individuals had language scores advanced by 1- to 3-months on their chronological ages, for many, substantial delays between 7- and 10-months were apparent.

Figure 5

Chronological age and mean age equivalence scores on receptive and expressive domains of the MacArthur-Bates Communicative Development Inventories (MCDI) and the Mullen Scales of Early Learning (MSEL) at baseline and follow-up



Note. Age equivalence score missing for MCDI receptive language due to fitted percentile scores only being available up to 18 months of age. Error bars represent standard errors. N=72. RL=Receptive language. EL=expressive language.

As shown in Table 3 and despite the substantial variability in child language age equivalence scores, infant chronological age *was* significantly correlated with language age equivalence scores at baseline, with the MSEL receptive and expressive domains (respectively, *r*s=.34 and .37, *p*<.01) and the MCDI receptive and expressive domains (respectively, *r*s=.26 and .38, *p*<.05 and *p*<.001).

Table 3

Raw scores and age equivalence scores (in months) on measures of receptive and expressive language at baseline and follow-up (N=72)

	Baseline (12-months)			
	MSEL		MCDI	
	M (SD) range	Significance test[a]	*M (SD)* range	Significance test
Receptive language				
Raw score	11.11 (2.99) 4-19		29.64 (36.23) 0-162	
Age equivalence score	9.29 (3.25) 2-18	t=-6.55, p<.001, d=0.90	9.24 (1.92) 8-15	t=-8.80, p<.001, d=1.27
Expressive language				
Raw score	8.79 (2.67) 4-15		0.86 (1.84) 0-11	
Age equivalence score	9.53 (2.40) 5-18	t=-9.36, p<.001, d=0.99	9.69 (1.23) 8-14	t=-9.24, p<.001, d=1.24
	Follow-up (24-months)			
	MSEL		MCDI	
	M (SD) range	Significance test	*M (SD)* range	Significance test
Receptive language				
Raw score	22.38 (5.98) 8-34		267.33 (151.92) 2-678	
Age equivalence score	22.55 (7.35) 6-39	t=-2.47, p<.05, d=0.38	- [b]	-
Expressive language				
Raw score	20.20 (5.54) 5-36		121.69 (128.45) 0-491	
Age equivalence score	21.09 (6.65) 4-42	t=-4.52, p<.001, d=0.71	18.13 (4.68) 9-28	t=-10.89, p<.001, d=1.77

Note. [a]t-test comparisons between chronological age (M=11.72, SD=1.97 at baseline and M=24.63, SD=2.22 at follow-up) and age equivalence scores on the language measures where age equivalence scores were available. [b]Age equivalence score missing for MCDI receptive language due to fitted percentile scores only being available up to 18 months of age. MSEL=Mullen Scales of Early Learning; MCDI = MacArthur-Bates Communicative Development Inventory.

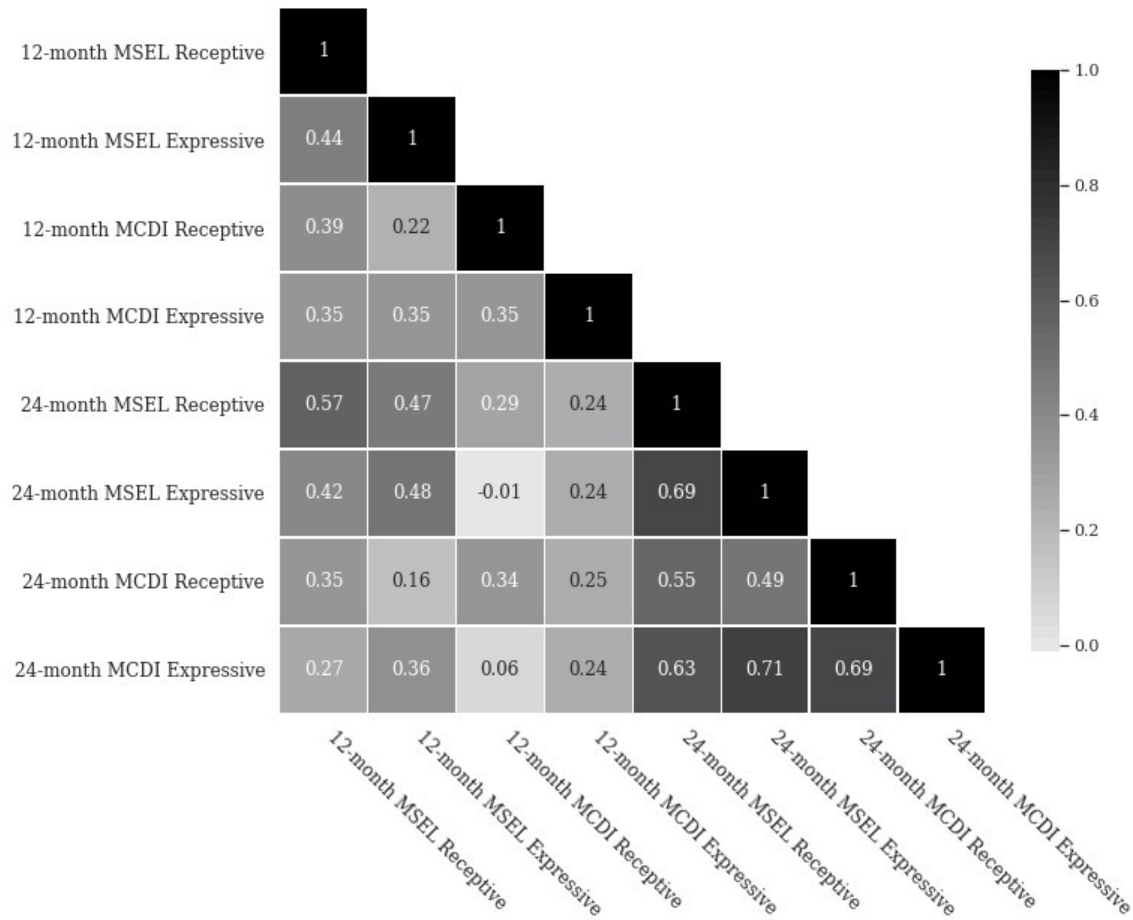
Consistency of Participant Language Abilities Across Measures

Pearson's correlations were computed to test Hypothesis 2, that infants' scores on the receptive and expressive language measures would be correlated with one another, both concurrently and prospectively. Given it was not possible to compute age equivalence scores for the MCDI at follow-up, and to ensure consistency across measures, raw scores for both the MSEL and MCDI were used here and these, along with age equivalence scores, are presented above in Table 3. As shown in Figure 6, scores on the various language measures were mostly significantly correlated with one another at both time points, with correlation coefficient values ranging from .24 to .71. There were three exceptions related to baseline and follow-up MCDI receptive scores (*r*s < .22 and non-significant).

At baseline and follow-up, like scales were strongly correlated with one another (e.g., MCDI receptive with MSEL receptive language; MCDI expressive with MSEL expressive language). As demonstrated in Figure 6, correlations between and within measures were stronger at follow-up assessment (i.e., when the children were older) than was the case at baseline assessment. Furthermore, at each timepoint, expressive language scales were more strongly correlated with one another across measures (i.e., MSEL expressive and MCDI expressive language) than were receptive language scales. There was also a stronger within-measure correlation over time for MSEL than for MCDI scores (i.e., stronger baseline to follow-up MSEL receptive correlations than baseline to follow-up MCDI receptive correlations). Finally, and unsurprisingly, the weakest associations were apparent in indicators of consistency over time (i.e., between baseline and follow-up assessment) *across* measures and domains (i.e., baseline MSEL receptive language with follow-up MCDI expressive language).

Figure 6

Pearson's correlations among raw score measures of receptive and expressive language at baseline and follow-up (N=72)



Note. The strength of correlation is demonstrated with the scale on the right, showing that paler grey is a weaker correlation, and darker grey is a stronger correlation. MSEL = Mullen Scales of Early Learning; MCDI = MacArthur-Bates Communicative Development Inventory.

Prelinguistic Intentional Communication

Of key interest to this study were the infants' early prelinguistic intentional communication skills. A majority of infants were rated as showing atypical RJA (80.56%), *not* orienting to the object pointed at by the health practitioner who made the SACS-R rating, with only a minority subgroup doing so and thereby rated as demonstrating typical RJA. Similarly, over half of the cohort were rated by the examiner as demonstrating poor IJA (58.00%; i.e., not engaging in social referencing), compared with 18.39% who demonstrated fair IJA (i.e., some social referencing) and 23.61% who demonstrated good use of IJA (i.e., consistent social referencing). Baseline scores on the MCDI 'First Communicative Gestures' form ranged between 1 and 12 (M=5.82, SD=3.15).

Associations between the different baseline measures of prelinguistic intentional communication skill were examined, with a chi-square group difference between infant RJA and IJA classifications indicating no significant effect (χ^2(2, n=72) =3.50, p=.174). More females were employed part-time compared to males (53% versus 39%), while more males were in full time employment (61% versus 47%).

An independent samples t-test did not report a significant difference between gesture use amongst infants with atypical (M=4.47, SD=2.99) compared with typical RJA skills (M=6.33, SD=3.70; t(68)= -1.89, p=.063), although a medium effect was found (d=0.55, 95% CI [0.08-1.02]). A one-way ANOVA comparing gesture use by infant IJA subgroup (i.e., poor, fair and good) showed no significant effect, F(2,69) =1.75, p=.182, η^2=0.05.

Prelinguistic Intentional Communication and Concurrent Language Abilities

T-tests were used to measure differences on the various language scales across the two RJA subgroups (i.e., typical [n=12] and atypical [n=58]). As shown in Table 4, independent samples t-tests did not report a significant effect for RJA subgroup for concurrent language skills. That is, no difference by RJA subgroup on MCDI receptive language, t(68)=-1.90, p=.062, d=0.57; or MCDI expressive language, t(68)=0.46, p=.642, d=-0.18. Similarly, no significant effect of RJA subgroup was found on MSEL receptive language, t(68)=0.60, p=.552, d=-0.17; or MSEL expressive language, t(68)=-0.50, p=.617, d=0.16.

Group differences were examined using a one-way ANOVA to compare scores on each of the language measures across the three subgroups of IJA: poor, fair and good. There was no significant effect of IJA subgroup on either MCDI measure – receptive language, $F(2,69)=1.09$, $p=.343$, $\eta^2=0.03$, or expressive language, $F(2,69)=0.49$, $p=.612$, $\eta^2=0.01$. There was also no significant effect of IJA subgroup on MSEL expressive language, $F(2,69)=2.60$, $p=.081$, $\eta^2=0.07$. Interestingly, infants with good IJA skills were found to have significantly *lower* MSEL receptive language scores ($M=9.29$, $SD=2.71$), compared to infants with fair IJA skills ($M=12.23$, $SD=3.70$, $p=.018$) who were higher than infants with poor ($M=11.50$, $SD=3.70$; $F(2,69)=4.88$, $p<.01$). Furthermore, the actual mean difference between IJA subgroups was quite large ($\eta^2=.124$).

Pearson's correlations were computed to measure associations between gesture use and concurrent language abilities. Baseline gesture use score was significantly positively correlated with concurrent scores on all four language measures – MSEL receptive ($r=.43$, p<.001) and expressive language ($r=.52$, p<.001), and MCDI receptive ($r=.44$, $p<.001$) and expressive language ($r=.51$, $p<.001$).

Table 4

T-test results comparing receptive and expressive language skills across typical and atypical response to joint attention groups

	Baseline (12-months)													
	MCDI Receptive							MCDI Expressive						
						95% CI for Cohens *d*							95% CI for Cohens *d*	
	M	*SD*	*t*	*p*	Cohen's *d*	Lower	Upper	M	SD	*t*	*p*	Cohen's *d*	Lower	Upper
Atypical RJA	23.19	24.61	-1.90	.062	0.57	0.10	1.04	0.84	1.90	0.46	.642	-0.18	-0.64	0.29
Typical RJA	38.42	28.58						0.58	0.90					
	MSEL Receptive							MSEL Expressive						
Atypical RJA	11.24	2.92	0.60	.553	-0.17	-0.64	0.29	9.45	2.46	-0.50	.617	0.16	-0.30	0.63
Typical RJA	10.67	3.58						9.83	2.21					
	Follow-up (24-months)													
	MCDI Receptive							MCDI Expressive						
Atypical RJA	269.62	159.75	0.20	.935	-0.01	-1.06	-0.12	115.16	110.84	-0.08	.935	0.04	-0.43	0.50
Typical RJA	259.75	37.03						118.08	35.94					
	MSEL Receptive							MSEL Expressive						
Atypical RJA	22.28	5.90	-0.03	.976	0.01	-0.45	0.47	20.28	3.62	-0.25	.803	0.08	-0.38	0.54
Typical RJA	22.33	6.93						20.58	3.85					

Note. Degrees of freedom = 68 for all analyses. Typical RJA n=12. Atypical RJA n=58.
M=Mean; SD=Standard deviation; MCDI = MacArthur-Bates Communicative Development Inventory; MSEL=Mullen Scales of Early Learning; RJA= Response to joint attention; IJA=Initiation of joint attention.

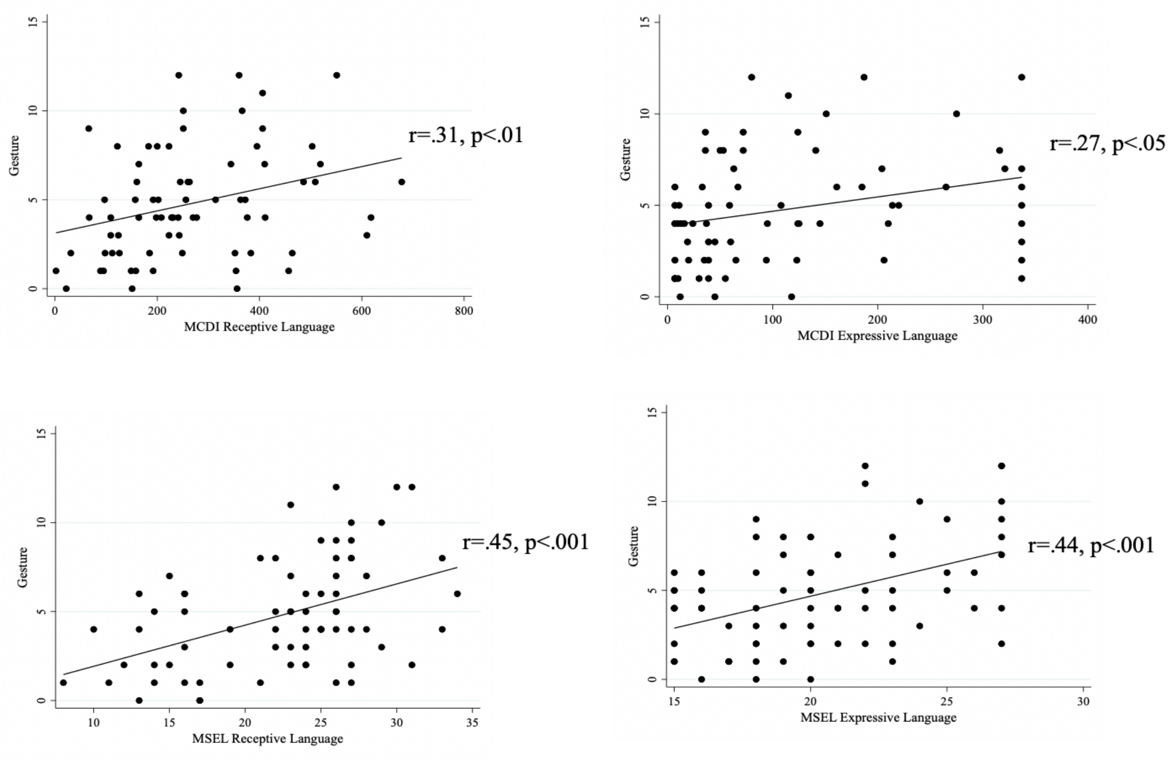
Prelinguistic Intentional Communication and Prospective Language Abilities

T-tests, ANOVAs and Pearson's correlations were used to test Hypothesis 4, that infants' baseline prelinguistic intentional communication skills would be prospectively associated with measures of language taken at follow-up assessment, one year later. T-tests were used to compare scores on the various language measures at follow-up assessment as a function of baseline RJA (i.e., rated typical and atypical). As observed in the test of concurrent associations with this measure, here too (as shown in Table 4) there was no significant predictive association of RJA subgroup for language outcomes; that is, no difference by RJA subgroup on MCDI receptive language, $t(68)= 0.20$, $p=.935$, d=-0.01, or MCDI expressive language, $t(68)=-0.08$, $p=.935$, d=0.04. Similarly, no significant effect for RJA condition was found on MSEL receptive language, $t(68)=-0.03$, $p=.976$, d=0.01, or MSEL expressive language, $t(68)=-.25$, $p=.803$, d=0.08.

A one-way ANOVA was used to compare scores on each of the language measures at follow-up assessment across the three subgroups of baseline IJA. There was no significant effect of IJA subgroup on either MCDI measure; receptive language, $F(2,69)=0.77$, $p=.467$, $\eta^2=0.02$, or expressive language, $F(2,69)=1.37$, $p=.261$, $\eta^2=0.04$. There was also a non-significant trend for such an effect on MSEL expressive language, $F(2,69)=2.99$, $p=.057$, $\eta^2=0.08$. As observed in the test of concurrent associations at baseline, there was again a significant effect of baseline IJA subgroup on prospective MSEL receptive language, $F(2,69)=8.93$, $p<.001$. Here, however, a Tukey post-hoc test revealed that MSEL receptive language at follow-up assessment was significantly *lower* for infants with poor IJA ($M=18.65$, $SD=3.75$) compared with infants with good IJA at baseline ($M=21.17$, $SD=3.95$, $p=.050$). The subgroup with fair IJA had intermediate receptive language scores ($M=19.77$, *SD*=3.11), not significantly different from either the subgroup with poor (*p*=.462) or good IJA skills (*p*=.689). Furthermore, the actual mean difference between IJA subgroups was quite large (η^2=.206). Pearson's correlations were computed to measure the prospective association of baseline gesture scores with subsequent language outcomes. As shown in Figure 7, baseline gesture score was significantly correlated with follow-up receptive and expressive language scores on both measures.

Figure 7

Associations between baseline gesture use scores and follow-up scores on the receptive and expressive scales of the MacArthur-Bates Communicative Development Inventories (MCDI) and the Mullen Scales of Early Learning (MSEL)



Note. N=72.

Descriptive characterisation of the extent of the infants' autism symptoms has been presented in Table 2, above. Briefly, infants at a group level demonstrated an average score of 8.79, with scores ranging from 1 to 28. To address Hypothesis 5, that baseline autism symptoms would be associated with each of the key measures described thus far, t-tests revealed no significant difference in baseline autism symptoms by RJA subgroup (i.e, typical vs. atypical rating), $t(68)=0.18$, $p=.857$. There was, however, a significant and large effect on baseline autism symptoms of IJA subgroup (poor IJA, fair IJA, good IJA), $F(2,69)=7.08$, $p<.001$, $\eta^2=.170$, with a Tukey post-hoc test revealing significantly higher autism symptoms among the subgroup of infants with poor IJA ($M=7.24$, $SD=3.75$) compared to those with good IJA ($M=11.47$, $SD=5.57$, $p=.002$), with no significant difference with fair IJA ($M=10.31$, $SD=3.68$, $p=.064$). A Pearson's correlation was computed and revealed a small and non-significant association between autism symptoms and gesture use ($r=-.16$, $p=.171$)

Finally, Pearson's correlations were also computed to test for potential associations between baseline autism symptoms and concurrent measures of language ability. These revealed little and no significant associations with baseline MCDI receptive language ($r=-.02$, $p=.855$) or MCDI expressive language ($r=.13$, $p=.115$). Similarly, no significant associations were found for baseline MSEL receptive language ($r=-.19$, $p=.115$), however, there was a non-significant trend towards poorer MSEL expressive language by autism symptoms ($r=-.23$, $p=.056$). Further, Pearson's correlations were also computed to test the *prospective* association between baseline autism symptoms and follow-up language scores, and here revealed small to moderate correlations found to be significant for three of these. That is, baseline autism symptoms were associated with subsequent MCDI expressive language ($r=-.25$, *p*<.05), MSEL receptive language (*r*=-.43, *p*<.001) and MSEL expressive language scores (*r*=-.37, *p*<.01), but not with MCDI receptive language scores (*r*=-.14, *p*=.234).

Predictive Value of Prelinguistic Intentional Communication for Later Language

To address the final study aim – Hypothesis 6, that early joint attention and gesture use would be predictive of later language ability, controlling for the potential contribution of emerging autism symptoms and baseline language ability – four separate hierarchical regression analyses were conducted; one for each of the key language measures. Variables entered as predictors into each regression were those for which significant correlations with the outcome variable of interest had been identified, and these were entered in the order described below to elucidate the added predictive value of the key variables of interest above and beyond the contribution of any observed continuity from baseline to follow-up language abilities, on the corresponding scale.

The first hierarchical regression concerned the prediction of MCDI receptive language at follow-up assessment. Here, baseline MCDI receptive language was entered at Step 1, followed by baseline gesture use at Step 2. Baseline joint attention and autism symptoms were not included in the model due to showing no bivariate association with this particular language outcome measure. As shown in Table 5, baseline MCDI receptive language was a significant predictor at Step 1, accounting for 11.3% of the variance in follow-up MCDI receptive language. Introducing gesture use at Step 2 explained a non-significant additional 3.4% of the variance, with both predictors in the final model accounting for 14.8% of the total variance in MCDI receptive language. That is, in the final model, only baseline MCDI receptive language ability carried significant unique predictive value for this same measure at follow-up, with no unique contribution of gesture use.

Table 5
Hierarchical regression for variables predicting MacArthur-Bates Communicative Development Inventory (MCDI) receptive language abilities (n=72)

		Unstandardised coefficients		Standardised coefficients					
Step	Predictor	*B*	*SE*	*β*	*p*	R^2	$R^2\,\Delta$	*F*	*p*
1						.11	-	8.96	.004
	Baseline MCDI RL	0.01	.00	.34	.004				
2						.18	.03	2.78	.100
	Baseline MCDI RL	.01	.00	.25	.040				
	Gesture	.06	.94	.20	.100				

Note. RL=Receptive language.

The second hierarchical regression concerned the prediction of MCDI expressive language at follow-up assessment, from baseline MCDI expressive language, entered at Step 1, and baseline autism symptoms and gesture use entered at Step 2. As shown in Table 6, baseline MCDI expressive language was a significant predictor at Step 1, accounting for 5.5% of the variance in follow-up MCDI expressive language. Introducing autism symptoms and gesture use at Step 2 explained a statistically significant additional 8.6% of variance, with all three predictors in the final model together accounting for 14.1% of the variance in MCDI expressive language. Interestingly, however, in the final model only baseline autism symptoms carried significant unique predictive value – with no unique contribution of gesture use, and with the baseline MCDI score no longer carrying predictive value.

Table 6

Hierarchical regression for variables predicting MacArthur-Bates Communicative Development Inventory (MCDI) expressive language abilities (n=72)

		Unstandardised coefficients		Standardised coefficients					
Step	Predictor	*B*	*SE*	*β*	*p*	R^2	$R^2 \Delta$	*F*	*p*
1						.05	-	4.04	.048
	Baseline MCDI EL	0.13	0.06	.23	.048				
2						.27	.09	9.73	.000
	Baseline MCDI EL	0.12	0.07	.22	.108				
	Autism symptoms	-0.06	0.03	-.26	.028				
	Gesture	0.03	0.04	.10	.484				

Note. EL=Expressive language.

The third hierarchical regression concerned the prediction of MSEL receptive language at follow-up assessment, with baseline MSEL receptive language entered at Step 1, followed by baseline autism symptoms, IJA subgroups (categories of fair vs poor and good vs poor), and gesture use all entered together at Step 2. As shown in Table 7, baseline MSEL receptive language was a significant predictor at Step 1, accounting for 32.9% of the variation in follow-up MSEL receptive language. Introducing autism symptoms, IJA subgroups and gesture use at Step 2 explained a statistically significant additional 20.4% of variance, with all five predictors in the final model together accounting for 53.3% of the variance in MSEL receptive language. Baseline MSEL continued to carry the strongest unique predictive value in the final model, with no significant unique contribution of IJA subgroup. Autism symptoms and gesture use contributed unique predictive value within the overall model.

Table 7

Hierarchical regression for variables predicting Mullen Scales of Early Learning (MSEL) receptive language abilities (n=72)

		Unstandardised coefficients		Standardised coefficients					
Step	Predictor	*B*	*SE*	*β*	*p*	R^2	$R^2 \Delta$	*F*	*p*
1						.33	-	34.31	.000
	Baseline MSEL RL	0.19	0.03	.57	.000				
2						.53	.20	7.19	.000
	Baseline MSEL RL	0.11	0.03	.33	.001				
	Autism symptoms	-0.07	0.02	-.31	.001				
	IJA								
	Fair (vs poor)	0.46	0.24	.18	.060				
	Good (vs poor)	-0.32	0.23	-.14	.169				
	Gesture	0.08	0.03	.24	.013				

Note. RL=Receptive language.

The final hierarchical regression concerned the prediction of MSEL expressive language at follow-up assessment, again with baseline MSEL expressive language entered at Step 1, followed by baseline autism symptoms and gesture use at Step 2. As shown in Table 8, baseline MSEL expressive language was a significant predictor at Step 1, accounting for 23.0% of the variance in follow-up MSEL expressive language. Introducing autism symptoms and gesture use at Step 2 explained a statistically significant additional 9.5% of variance, with all three predictors in the final model together accounting for 32.6% of the variance in MSEL expressive language. Interestingly, baseline MSEL expressive language ability continued to carry significant unique predictive value, and additional unique variance of autism symptoms. However, gesture use carried no significant unique predictive value for MSEL expressive language.

Table 8

Hierarchical regression for variables predicting Mullen Scales of Early Learning (MSEL) expressive language abilities (n=72)

		Unstandardised coefficients		Standardised coefficients					
Step	Predictor	*B*	*SE*	*β*	*p*	R^2	$R^2 \Delta$	*F*	*p*
1						.23	-	21.03	.000
	Baseline MSEL EL	0.20	0.04	.48	.000				
2						.34	.10	4.82	.011
	Baseline MSEL EL	0.14	0.05	.32	.008				
	Autism symptoms	-.06	0.02	-.26	.012				
	Gesture	0.06	0.04	.19	.114				

Note. EL=Expressive language.

Chapter 4: Discussion

Overview of Study Aims

The importance of prelinguistic intentional communication and language delay in children with autism, and of language in child development more broadly, is widely acknowledged. Indeed, decades of communication research in autism has demonstrated numerous predictors of language development, but most especially a cluster of skills known collectively as prelinguistic intentional communication skills (Keen et al., 2016). Much of the research to date on prelinguistic intentional communication and subsequent language ability in the context of autism has occurred in children post-diagnosis, beyond the key normative early period of language acquisition. Where prelinguistic intentional communication and language skills have been investigated during the normative developmental period when these emerge, in children with autism, this has traditionally been via retrospective methods or, more recently, via prospective methods that leverages the high recurrence rate of autism among high-risk infant siblings. However, both of these approaches potentially introduce bias, including recall/sampling biases for retrospective studies, and also potential sampling bias with regards to high-risk infant sibling cohorts, with emerging research suggesting this subgroup may not be representative of all autism (Sacrey et al., 2017). Furthermore, previous research has utilised varying language measures, reducing the ability to draw direct comparisons across studies and to draw confident inferences that synthesise across individual research findings.

Often considered as being the foundation on which many other communication and social skills are built, the absence or impairment of prelinguistic intentional communication skills represents among the clearest early markers of emerging autism and key symptoms of the condition post-diagnosis (Charman, 2003; Travis & Sigman, 2001). Prelinguistic intentional communication skills are therefore potentially important early indicators of both autism itself and of subsequent language deficits. The research presented in this study represents an initial exploration of the relationship between prelinguistic intentional communication and language development in infants with possible emerging autism – identified early in life but in a manner *other* than the conventional high-risk infant sibling design and followed prospectively from 12- to 24-months of age. The overarching objectives of this study were, firstly, to profile the early prelinguistic intentional communication and receptive and expressive language abilities of this unique community-referred sample of infants with possible emerging autism, and secondly, to evaluate the predictive value of early prelinguistic intentional communication skills for language development across a one-year follow-up period. This was approached through testing six pre-specified hypotheses, each of which will be considered in turn.

Early Language Abilities of Infants with Emerging Autism

Hypothesis 1 concerned whether infants with possible emerging autism would demonstrate poorer receptive and expressive language skills compared with age-related scores from the standardisation samples on both direct assessment and parent-report measures. Each was administered twice with the infants; mean ages 11.72 (range 9- to 16-months) and 24.63 months (range 21- to 30-months). Indeed, the infants as a group had poorer receptive and expressive language skills at both baseline and follow-up assessments, relative to mean chronological age, with group-level delay averaging 2- to 3-months in these skills at both timepoints. Furthermore, while some infants had language scores advanced by 1- to 3-months on their chronological ages, for many, substantial delays between 7- and 10-months were apparent.

These findings, from a novel community-referred cohort, support those from the few studies that have investigated language abilities in community-referred infants with emerging autism. For example, Barbaro and Dissanayake (2012) showed that children recruited via community referral pathways and later diagnosed with autism demonstrated relatively poorer receptive and expressive language skills, compared with developmental abilities in other non-language related domains; visual reception and fine motor skills. In another Australian community-based study of 1,021 children (41 with autism, 119 with language impairment and 861 with typical development), children with autism had poorer language relative to typically developing children and language delayed children at 2 years of age (Brignell, 2016).

This finding is also consistent with results from prospective studies of language in emerging autism that have adopted the high-risk infant sibling design and sampled clinic-referred (and not community referred) infants and toddlers (Chawarska et al., 2016; Landa & Garrett-Mayer, 2006; Landa et al., 2007). For example, Chawarska et al. (2016) investigated the early developmental profiles of 89 infants who were referred to the research due to concerns regarding their cognitive, language and/or social development, both with and without concerns regarding autism. Also using the MSEL, researchers found language abilities to be more impaired in children who were later diagnosed with autism.

That infants with emerging autism – recruited via various methods - showed delays that could have signalled early language difficulties may not be surprising, however, are cause for concern given accumulating evidence of the association between early language abilities and subsequent cognitive and adaptive functioning

(Anderson et al., 2007; Luyster, Kadlec, Carter, & Tager-Flusberg, 2008). Indeed, language difficulties in young children, irrespective of an autism diagnosis, could pose significant challenges for continued learning and social interaction (McDuffie et al., 2005). Evidence presented here – demonstrating that signs of language delay can present as early as 12-months of age – has potentially important clinical implications. Given the substantial heterogeneity in typical language skills observed at 12-months of age, clinicians may not be immediately concerned when a child shows language delays at such a young age (Fenson et al., 2007), and indeed may not take note of small differences to the norms in terms of age equivalence. However, these findings highlight the relevance of identifying early lags in language development in order to provide appropriate pre-emptive supports to families, thereby reducing the risk of increasing delays that may prove intractable as a child moves into school with its heavy reliance on sound language skills required for reading and other academic learning. Certainly, research on this topic may be an avenue worthy of exploring to improve receptive and expressive language skills in infants with emerging autism. Future research is also warranted to elucidate the overlapping features with early language skills across language disorders and autism (Paul et al., 2018). Research has demonstrated the importance of better understanding the developmental trajectories of language and how they differ across children with a language disorder, autism and typical development (Brignell, 2016). Further research is needed to better understand the language trajectories amongst infants and children given the literature suggesting a large natural variation in the rate at which a child's language may develop (Reilly et al., 2010; Rice et al., 2008; Ukoumunne et al., 2012). For example, Reilly et al. (2010) showed that around 70% of late-talking 2 year old's (who did not have comorbid developmental conditions) had "caught up" by 4 years of age (Reilly et al., 2010).

Other studies report similar findings, estimating around 75% of late-talkers demonstrate language within the normal range on standardised language testing by 3 years (Rice et al., 2008). However, there are some reports late-talkers have weaker language than non-late-talkers throughout childhood and are at greater risk for difficulties with literacy and high-order language tasks (Rescorla, 2009), while the 25-30% of children who fail to catch-up are at risk of long-term detrimental effects.

Hypothesis 2 investigated associations between two measures of language – the direct assessment Mullen Scales of Early Learning (MSEL) and the parent-report MacArthur-Bates Communicative Development Inventories (MCDI) – each including receptive and expressive domains, when assessed concurrently at the same timepoint and also prospectively from baseline to follow-up. Almost all measures at both time points were significantly correlated with one another (with three exceptions relating to MCDI receptive language scores). The current concurrent associations are consistent with findings from previous literature investigating language development in children with autism, such as Luyster et al.'s (2008) study of children with autism aged 18- to 33-months showing significant correlations amongst three measures of language – two of which were included in this study – suggesting convergent measurement validity.

Interestingly, however, past research including that of Luyster et al. (2008) and others (Charman et al., 2005; Sigman & McGovern, 2005; Siller & Sigman, 2002) has consistently demonstrated *strong* correlations among language measures – with effects >.8 – whereas those observed here were more variable, including some small but significant associations (.24) alongside stronger ones (.71). The apparent discrepancy between the current findings and previous research may be in part explained by the fact that the current group of infants with possible emerging autism were highly varied across all measures – compared with more homogenous groups in past research, including samples of children recruited exclusively *with* autism or indeed samples exclusively *without* autism. Although the infants in this sample were recruited on the basis of showing early signs of autism, it was not yet possible to know, from the current data, which of the children in this sample were indeed on a developmental trajectory toward eventual autism diagnosis. Therefore, whilst the sample of infants was heterogeneous at the time of recruitment, and this was corroborated by assessments administered at baseline assessment, it is likely they will also have heterogeneous outcomes – more so than represented in previous studies on this topic – and thereby have experienced heterogeneous developmental trajectories.

This is one of the first studies to demonstrate prospective correlations between language measures taken at earlier compared with later points in time, in a cohort of infants identified via community-referral based on the presentation of early behavioural signs of autism. It is, however, important to note some of the differences among the measures at both timepoints. At both baseline and follow-up assessments, like scales were highly correlated with one another. For example, prospective associations were strongest between scores on the *same* domain assessed using the *same* measure, compared with scores on the *alternate* domain and/or measure. Interestingly, at each timepoint, scores on the expressive domain were more strongly correlated across measures than were scores on the receptive domains. One interpretation of this differential strength of effect across expressive and receptive domains could be related to standardised assessments of receptive language often relying on a child to be *socially motivated* to demonstrate understanding. This can be through gaze or through other forms of social communication to demonstrate that they have *understood* what is being asked of them (Senju, 2013). That is, the more variable apparent receptive language performance of infants, evidence across the different approaches to receptive language assessment may reflect true instability in this domain, or the inherent difficulty measuring receptive language in young children and children with autism, related to behavioural and motivational factors.

Finally, there was a clear pattern such that correlations between and within measures were stronger at follow-up assessment – when the children were older – than at baseline assessment. This is unsurprising, given that many infants aged 12-months (including typically developing infants) have fairly limited and inconsistent use of language. This could mean that there would have been a reduced range of scores on measures at the baseline assessment (compared with a wider range of scores at follow-up) thereby constraining the extent to which measures could be strongly associated with one another.

Prelinguistic Intentional Communication and Language Abilities

Hypotheses 3 and 4 concerned concurrent and prospective associations between early prelinguistic intentional communication skills – here, joint attention and gesture use – and measures of receptive and expressive language. A majority of infants demonstrated atypical response to joint attention (RJA; i.e., not looking to an object that an examiner is pointing to) and poor use of initiation of joint attention (IJA; i.e., not engaging in any instances of social referencing). While each of the joint attention measures was derived from single-item scores within broader assessments of autism symptom presentation, and categorical rather than continuous in nature, a certain level of heterogeneity of joint attention skills in this group was evidenced. It was not the case that all infants were categorically impaired in their joint attention skills. That is, a sizeable subgroup (80.56%) demonstrated atypical RJA, and a similarly sizeable subgroup demonstrated poor IJA (58.00%). Furthermore, it was not simply that these joint attention measures were classifying the same children as more or less atypical, as there was no association between these two measures. Finally, there were no significant associations between any of the measures of gesture use, RJA or IJA.

No significant associations were found between the RJA measure and receptive or expressive language at either timepoint. IJA, by contrast, was significantly correlated with receptive language scores from direct assessment (but not parent-report). This was the case at both baseline and follow-up assessments; however, with a different pattern of effects when the omnibus test was followed up. Interestingly, infants with good IJA had worse MSEL receptive language at baseline, however, this result was as expected at follow-up (i.e., infants with good IJA had better MSEL receptive language). Further, there was a non-significant trend toward association between IJA and expressive language scores on the same direct assessment measure (and again, not on the parent-report measure) at both timepoints.

This set of results is somewhat surprising. A substantial portion of the literature on prelinguistic predictors of language ability has demonstrated concurrent and prospective associations between joint attention and language skills (e.g., Carpenter et al., 1998; Mundy, 2017), although these studies did investigate associations in groups of children who were older and had established autism diagnoses. Furthermore, there is also inconsistency in the literature. For example, in a study of thirteen typically developing children aged around 20-months, the findings of Charman et al. (2001) were similar to the current results, in that measures of joint attention were not associated with concurrent language ability. Further consideration of these points will be addressed below.

Early gesture use was significantly correlated with measures of receptive and expressive language, both concurrently at baseline, and prospectively at follow-up. This is consistent with other research which has also demonstrated correlations between gesture use and language ability in both typically developing children (Carpenter et al., 1998) and children with autism (Rowe & Goldin-Meadow, 2009). Furthermore, the importance of gesture use for concurrent and prospective language ability has also been shown in a study by Luyster et al. (2008) of siblings of children diagnosed with autism, whereby gesture use was shown to be the most robust (above and beyond the effect of imitation, joint attention and age) and consistent predictor of both receptive and expressive language.

The findings presented here, along with those from the existing literature, support theories of language development that emphasise the close relationship between gesture use and language development (Thal & Bates, 1988). It has been suggested that early gestures, such as pointing, are a prelinguistic method by which children communicate (Goldin-Meadow, 2007), often characterised as creating a bridge between their earlier-emerging language comprehension and later-emerging production skills. That is, infant gesture use is considered to have a role in scaffolding language development from understanding to spoken ability (Charman, Baron-Cohen, et al., 2003; Fenson et al., 1994).

Early gesture use has a clear role to play, clinically, as a means of identifying and supporting children early who may be at risk of subsequent and ongoing language deficits. Future research could employ the use of a scale such as the CSBS (Wetherby & Prizant, 2002), a parent-report checklist that provides a measure of seven key language predictors (including gestures). Gesture use has the potential to be a useful element in parent education and early intervention efforts surrounding language development and may be a powerful tool in supporting and reinforcing children's links to word learning. In conjunction with existing literature, the results reported here suggest that formal assessment of gesture use could be highly informative alongside formal measurement of language abilities during this prelinguistic phase.

Prelinguistic Intentional Communication and Autism Symptoms

Hypothesis 5 concerned the association between autism symptoms, measured on a continuous scale by the Autism Observation Scale for Infants (AOSI; Bryson et al., 2008), and each of joint attention and gesture use as prelinguistic intentional communication skills and language ability. Infants in this cohort demonstrated an average AOSI score of 8.79, with wide range of scores between 1 (virtually no early signs of autism) to 28 (very substantial evidence of behaviours related to autism). Results revealed little correlation between autism symptom presentation and baseline language ability, gesture use or joint attention. However, interestingly, significant correlations were apparent between baseline autism symptoms and subsequent measures of receptive and expressive language at follow-up, on the MSEL and subsequent expressive language on the MCDI. This is one of the first studies to demonstrate the predictive value of early autism symptoms for subsequent language development, in contrast to much of the literature that focuses on the importance of early language ability for subsequent autism symptom severity (e.g., Kjelgaard & Tager-Flusberg, 2001; Mody & Belliveau, 2013). The current findings have some convergence with data from a very recent study of autism risk in a sample of 18 infants (average age 12-months) with Down syndrome (Hahn et al., 2020), whereby significant associations were demonstrated between infants AOSI scores indexing autism symptoms and concurrent MSEL expressive language scores. This particular study included only concurrent assessment, and not also follow-up assessment, so it is not clear whether a similar prospective association might be associated as was the case in this study.

The results presented here – that early autism symptoms predict subsequent language ability – potentially demonstrates the utility of assessing autism symptoms early in infancy, not just for identifying children who may be at risk of developing autism, but also for identifying children who may be at risk of subsequent language delay. Although the lack of concurrent association is interesting – and somewhat surprising given known associations of language and autism symptoms in the wider literature (albeit in older children, or in different risk cohort; Charman, et al., 2003; Clifford et al., 2007; McDaniel et al., 2017) – this may be related to the young age of the infants in this cohort. Further, and as discussed above, it may be that infants at 12-months (both in general but also in the current cohort) have fairly limited and inconsistent use of language, and therefore the potentially restricted range of earlier scores may limit the statistical evidence for an association between variables at baseline. Furthermore, the predictive utility of early autism symptoms and subsequent language ability is interesting given much of the broader literature has focused on the predictive value of poor language and subsequent autism diagnosis, rather than early autism symptoms as being predictive of subsequent language difficulties. Finally, much of the existing literature does not consider non-verbal cognition or IQ as a potential covariate. Future research should consider non-verbal cognition and/or IQ when considering early autism symptoms and later language development.

Predictive Value of Prelinguistic Intentional Communication

Finally, addressing Hypothesis 6 and the key issue of interest in this research, was identifying which among early autism symptoms and the examined prelinguistic intentional communication skills were predictive – together and uniquely – of later receptive and expressive language abilities. Four regression models were run – one on each of the direct assessed and parent-reported receptive and expressive language measures – with baseline measures that were found to be prospectively correlated with each language measure entered as potential predictors. In each regression model, baseline levels of the outcome measure of interest were entered first and confirmed to be relevant predictors of the same measure at follow-up. This suggested stability in the measures over time, a factor that remained evident even when other predictors were subsequently entered into the models – except in the single case of MCDI expressive language, where the unique predictive value/stability of baseline expressive language level was no longer apparent when other factors were included in the regression.

The robust continuity of early language skills for the prediction of later language outcomes can be understood in the context of substantial research on typical acquisition. One area of early language development that has received concentrated research focus is the mechanism by which infants are able to perceive meaningful components of speech to which they are exposed to in varying situations (e.g., Aslin et al., 1998). The task of learning language could initially be facilitated by an infant's ability to perceive the intricacies associated with spoken language (Aldridge et al., 2001; Eimas et al., 1971; Maye et al., 2002) and indeed individual differences in early speech perception abilities have been found to predict language development by 24-months of age in several longitudinal studies (Fernald et al., 2006; Tsao et al., 2004).

This suggests a virtuous cycle by which any early language ability (i.e., ability to perceive the intricacies associated with spoken language) might facilitate an infant's early speech perception abilities, which in turn further facilitates later language development.

Beyond baseline language abilities, baseline autism symptoms – significantly correlated with three of the language measures (for the exception was MCDI receptive language) and therefore included in the regressions – also contributed unique predictive value alongside other included predictors. Specifically, this was the case for each of MSEL receptive language, and for both MSEL and MCDI expressive language. Indeed, in the case of MCDI expressive language, autism symptoms were found to supersede the value of *all* other predictors, including the aforementioned apparent stability of the baseline measure for that same scale.

These results suggest that the AOSI may be measuring a set of skills that may be at once indicative of likely future autism (Brian et al., 2008) and also of potential difficulties with language development. Further, and as demonstrated in the regression results, this measure might be specifically telling about the development of expressive vocabulary production. Similarly, in a study of 35 young children (aged 20- to 71-months) with autism, Smith and Mirenda (2007) demonstrated vocabulary growth over time to be associated with greater earlier verbal imitation skills and pretend use of objects. Hence, an alternative explanation for the current results concerning the predictive value of AOSI scores for later expressive vocabulary could be related to the overlap between early autism symptoms as measured by the AOSI and skills related to socialisation and adaption to the social environment, being predictive of language. Indeed, in a follow-up study of 129 children with autism, autism severity at age 2.5 years was shown to be a significant predictor of both language comprehension and production at age 5.5 years (Weismer & Kover, 2015). Finally, in a study of 59 children with autism aged 2- to 5-years, Thurm et al. (2007) showed that the adaptive socialisation score on the Vineland Adaptive Behavior Scale (VABS) at age 2 predicted around a fifth of the variance in receptive and expressive language, potentially demonstrating the overlap between early adaptive socialisation and autism symptoms and relationships with subsequent language ability. Interestingly, however, these associations were no longer significant after controlling for IQ. These results, and the results of previous research, suggest the potentially important predictive value of early autism symptoms in predicting later language ability whilst also validating the need for further research considering the impact of IQ.

Results from the regression analyses also revealed that the apparent relevance of gesture use for subsequent language outcomes was inconsistent, when included among other predictors. Gesture use remained a significant unique predictor of MSEL receptive language skills – even alongside baseline stability of the same measure, and the contribution of autism symptoms. However, the apparent relevance of gesture use for predicting expressive language outcomes (on both the MCDI and MSEL) was otherwise absorbed by variance shared with autism symptoms, and not contributing further unique predictive value. Further to the above results related to joint attention, no associations or predictive value was demonstrated for RJA or IJA.

Interestingly, similar results were found in a study conducted by Manwaring et al. (2017) of 110 children with autism aged 35-months. Utilising the Communication and Symbolic Behavior Scales Developmental Profile Caregiver Questionnaire (CQ) and receptive and expressive language outcomes using the MSEL, Manwaring et al. (2017) showed that gesture use at 35 months significantly predicted VABS receptive language but not MSEL receptive language around 13-months later, above and beyond nonverbal cognition, autism severity, chronological age and baseline receptive language. Furthermore, gesture use at 35-months did not predict expressive language around 13-months later, on any of the language measures used (VABS or MSEL).

Results from the regression analyses also demonstrated the unique predictive value of gesture use, demonstrating its importance in supporting and identifying language delays in infants with possible emerging autism. As suggested by Sauer et al. (2010), examining early gesture use can potentially provide clinicians with a strategy to identify children who may go on to develop persistent language deficits, before the delays are seen in the child’s spoken language. Gesture use has the potential to become a key focus of any intervention strategy developed to address current and possible future delays in language abilities.

Limitations and Future Directions

While this study adopted a prospective design to investigate prelinguistic intentional communication and language development in infants with emerging autism, there are a number of limitations to the study design and execution that warrant consideration. Firstly, the current study did not benefit fully from the strengths of a longitudinal design in that data were only analysed across two assessment time-points (i.e., rather than three or more which might allow more thorough characterisation of trajectories of early language development). Furthermore, data were not yet available for the infants followed up to the time at which an autism diagnostic decision might be made. Hence, while early autism risk and symptoms were measured, and the impact of these for subsequent language outcomes explored, it was not possible to disaggregate results by diagnostic category. This would have enabled an examination of trajectories of language development toward particular outcomes – and the predictors thereof – to determine whether pathways from early prelinguistic intentional communication skills to language outcomes might vary for children with or without true emerging autism. Nevertheless, the continuous measure of autism symptoms available from the AOSI was included, varying suitably for inclusion as a potential predictor of language outcomes within the regression analyses, and demonstrating scores similar to those found in populations of high-risk infant siblings and groups of children who are subsequently diagnosed with autism (Bedford et al., 2017; Gliga et al., 2015).

Autism symptoms were observed under standardised conditions which minimised environmental variation and allowed the collection of comparable data across all participants. However, the AOSI is a measure of early risk behaviours, not a clinically-validated measure to inform very early diagnosis, and decisive diagnostic decisions for autism cannot be confidently made until late toddlerhood/early childhood (i.e., around the age of 3 years within the protocol of the larger study from which the current data were drawn). Future analyses with this cohort, once children have been assigned diagnostic outcome classifications, will enable further exploration of the impact of prelinguistic intentional communication and language development in a cohort of infants with emerging autism, including extending the temporal associations into early childhood (i.e., age 3 years) when language should be better developed than at the current outcome timepoint, and allowing the examination of differences by diagnostic groups– including potentially children with autism, development delay, language delay, and typical developmental. Extending these findings longitudinally (i.e., over more than two timepoints), will also be important to investigate factors that predict later stages of language development into the preschool years, and to specific domains of language such as grammatical skills and pragmatic abilities.

Secondly, this study considered language across two domains (receptive and expressive language) and two measures (one parent-report and one direct assessment), following literature demonstrating the usefulness of including multiple measures of language to achieve a better representation of children's language abilities (Luyster et al., 2008). Future research could include additional language assessments such as the New Reynell Developmental Language Scales (NRDLS; Edwards et al., 2011) or the CSBS (Wetherby & Prizant, 2002). Due to the nature of this study work being aligned with a larger study, where there were two measures of language ability, measures of autism symptom presentation, but no specific standardised measure of joint attention (such as the Early Social Communication Scales; Mundy et al., 2003) – it was necessary to derive measures of joint attention from items within the available autism symptom measures. Measuring RJA and IJA via purpose-built tools such as the ESCS may have provided more specific insights into the contributions of joint attention skill with language development in this cohort and offered comparability with the results from previous research on this topic with other types of cohorts and study design. Nevertheless, the current data showed infants *were* more delayed in their gesture use than general-population samples and were more often rated as having atypical than typical RJA and poor than fair or good IJA – consistent with the literature on infants at higher likelihood of autism to date (e.g., D'Souza et al., 2017; Gliga et al., 2012; Mitchell et al., 2006) – gives some confidence in the fit-for-purpose of these derived measures.

Thirdly, the selection of joint attention and gesture use as key prelinguistic intentional communication behaviours of interest for this study was on the basis of research indicating their developmental significance for language outcomes (e.g., Bedford et al., 2013; Gliga et al., 2012; Jones et al., 2014). However, additional components of prelinguistic intentional communication, such as babbling/prelinguistic vocalisation and broader gaze behaviours such as directed eye-contact, may have provided further insights into the impact of prelinguistic intentional communication on subsequent language development in infants with emerging autism. It is interesting to note that the overall amount of variance accounted for by the predictors entered into the current regression equations on outcome language abilities was relatively small if somewhat variable – 14% for each of MCDI receptive and expressive language, but 53% for MSEL receptive language and 33% for MSEL expressive language. In each case, substantial variance remained unaccounted for. Future research could focus on other predictors that may be related to early language development in children with emerging autism that were not included here, including the other prelinguistic intentional communication type skills noted above, but also other factors such as parental linguistic input and social play (Siller & Sigman, 2002).

The measure of gesture use utilised in this study was derived from the MCDI, with items combining imperative (requesting behaviours, e.g., “requests something by extending arm and opening and closing hand”), declarative (requesting attention, e.g., “extends arm to show you something he/she is holding”) and conventional (e.g., “smacks lips in a ‘yum yum’ gesture to indicate that something tastes good”) gestures within the one scale. Hence, it was not possible to uncover whether certain gesture subtypes might be more or less important in terms of predicting subsequent language ability. Given the importance of gesture use in developing language as demonstrated in this study, and that different categories of gestures may be differentially associated with distinctive receptive and expressive language milestones (Bates & Dick, 2002), future analysis could address the possibility that certain gestures may be differentially predictive of later language development specifically in the context of young children with emerging autism.

While the analytic approach adopted for this study leveraged sample heterogeneity to investigate the developmental predictors of language development – using correlation/regression-based analysis with data from a heterogeneous cohort – the relatively small sample size limited the statistical power to conduct more complex analyses (Schoemann et al., 2017), including investigating other potential predictors of language development (such as abnormal vocalisations or parent linguistic input as outlined above). However, the sample size exceeding 70 infants was suitable for the analyses conducted here and is commensurate with sample sizes from other research on early development in autism. Furthermore, preliminary analyses conducted here demonstrated no notable differences between the subset of the larger study cohort that was included in this study, due to complete data on key measures of interest, compared with the excluded subgroup of infants who were lost to follow-up or had missing data, suggesting the current findings should generalise to the larger sample of community referred infants initially recruited. That is, the retained subsample was not a biased subset of the entire recruited group, such as reflecting only those of a particular age or autism symptom severity. Nevertheless, future research with larger sample sizes and data collection at more timepoints would permit the conduct of more sophisticated statistical modelling to corroborate and extend upon the findings from this initial exploration of prelinguistic intentional communication and language in infants with emerging autism and engender confidence in the applicability of results to the larger population from which the sample was drawn. Furthermore, a larger sample size would enable further investigation of the possible effects of chronological age, gender and IQ.

Finally, studies examining the transactional effect on communication partners in a child's environment can further advance our understanding of the effect such a transactional influence may have on a child's skills outside of a laboratory setting. Indeed, such research is required to facilitate the development of parent-lead interventions that might prove to be effective in mitigating the risks of poor language development in the context of identified emerging autism. This will be critically important given the developing research showing the impact of early language delays on adolescent and adult wellbeing and adaptive functioning outcomes.

Conclusions

In conclusion, this study provided evidence for the predictive association of prelinguistic intentional communication skills and early autism symptoms on the subsequent language abilities – both receptive and expressive measured from direct assessment and parent-report – in a novel sample of infants with possible emerging autism recruited via community referral pathways. The findings demonstrated here showed continuity of early language skills for the prediction of later language outcomes. Findings also showed the importance of early autism symptoms in predicting expressive vocabulary skills and the predictive value of early gesture use and subsequent language ability. The continued investigation of longitudinal associations and early-life developmental trajectories of infants with possible emerging autism appears critical to detecting the emergence of meaningful individual differences, and the timing thereof, amongst infants with evolving and differing language abilities. Spoken language should be viewed from a developmental perspective and interventions should target not only improving infants' production of sounds and words and understanding of word meanings, but also the broader set of social-cognitive skills that appear to be closely linked to the development of language in infants with possible emerging autism as in infants following a more normative developmental pathway. This may have implications for how early intervention and identification can be tailored, with regards to specific early prelinguistic intentional communication delays, to meet the language needs of children with emerging autism during the first two years of life.

References

Adamson, L. B., Bakeman, R., Deckner, D. F., & Romski, M. (2009). Joint engagement and the emergence of language in children with autism and down syndrome. *Journal of Autism and Developmental Disorders*, *39*(1), 84–96. https://doi.org/10.1007/s10803-008-0601-7

Adamson, L. B., Bakeman, R., Suma, K., & Robins, D. L. (2017). An expanded view of joint attention: Skill, engagement, and language in typical development and autism. *Child Development*, *90*(1), 1–10. https://doi.org/10.1111/cdev.12973

Aldridge, M. A., Stillman, R. D., & Bower, T. G. R. (2001). Newborn categorization of vowel-like sounds. *Developmental Science*, *4*(2), 220–232. https://doi.org/10.1111/1467-7687.00167

American Psychiatric Association. (2013). Neurodevelopmental disorders. In *Diagnostic and statistical manual of mental disorders* (5th ed.). Author. https://doi.org/10.1176/appi.books.9780890425596

Anderson, D. K., Lord, C., Risi, S., Dilavore, P. S., Shulman, C., Thurm, A., Welch, K., & Pickles, A. (2007). Patterns of growth in verbal abilities among children with autism spectrum disorder. *Journal of Consulting and Clinical Psychology*, *75*(4), 594–604. https://doi.org/10.1037/0022-006X.75.4.594

Arunachalam, S., & Luyster, R. J. (2018). Lexical development in young children with autism spectrum disorder (ASD): How ASD may affect intake from the input. *Journal of Speech, Language, and Hearing Research*, *61*(11), 2659–2672. https://doi.org/10.1044/2018_JSLHR-L-RSAUT-18-0024

Aslin, R. N., Jusczyk, P. W., & Pisoni, D. B. (1998). Speech and auditory processing during infancy: Constraints on and precursors to language. In W. Damon (Ed.), *Handbook of child psychology: Volume 2: Cognition, perception, and language.* (pp. 147–198). John Wiley & Sons.

Baird, G., Charman, T., Pickles, A., Chandler, S., Loucas, T., Meldrum, D., Carcani-Rathwell, I., Serkana, S., & Simonoff, E. (2008). Regression, developmental trajectory and associated problems in disorders in the autism spectrum: The SNAP study. *Journal of Autism and Developmental Disorders*, *38*, 1827–1836.

Bakeman, R., & Adamson, L. B. (1984). Coordinating attention to people and objects in mother-infant and peer-infant interaction. *Child Development*, *55*(4), 1278–1289. https://doi.org/10.2307/1129997

Barbaro, J., & Dissanayake, C. (2009). Autism spectrum disorders in infancy and toddlerhood: A review of the evidence on early signs, early identification tools, and early diagnosis. *Journal of Developmental and Behavioral Pediatrics*, *30*(5), 447–459. https://doi.org/10.1097/DBP.0b013e3181ba0f9f

Barbaro, J., & Dissanayake, C. (2010a). Prospective identification of autism spectrum disorders in infancy and toddlerhood using developmental surveillance: The social attention and communication study. *Journal of Developmental and Behavioral Pediatrics*, *31*(5), 376–385. https://doi.org/10.1097/DBP.0b013e3181df7f3c

Barbaro, J., & Dissanayake, C. (2010b). Spectrum disorders in infancy and toddlerhood using developmental surveillance: The social attention and prospective identification of autism spectrum disorders in infancy and toddlerhood using developmental surveillance. *Journal of Developmental and Behavioral Pediatrics*, *31*(5), 376–385. https://doi.org/10.1097/DBP.0b013e3181df7f3c

Barbaro, J., & Dissanayake, C. (2012). Developmental profiles of infants and toddlers with autism spectrum disorders identified prospectively in a community-based setting. *Journal of Autism and Developmental Disorders*, *42*(9), 1939–1948. https://doi.org/10.1007/s10803-012-1441-z

Barbaro, J., & Dissanayake, C. (2013). Early markers of autism spectrum disorders in infants and toddlers prospectively identified in the Social Attention and Communication Study. *Autism*, *17*(1), 64–86. https://doi.org/10.1177/1362361312442597

Barger, B. D., Campbell, J. M., & McDonough, J. D. (2013). Prevalence and onset of regression within autism spectrum disorders: A meta-analytic review. *Journal of Autism and Developmental Disorders*, *43*(4), 817–828. https://doi.org/10.1007/s10803-012-1621-x

Bates, E., & Dick, F. (2002). Language, gesture, and the developing brain. *Developmental Psychobiology*, *40*(3), 293–310. https://doi.org/10.1002/dev.10034

Bayley, N. (2006). *Bayley-III: Bayley Scales ofInfant and Toddler Development* (3rd ed.). Pearson Education, Inc.

Bedford, R., Gliga, T., Frame, K., Hudry, K., Chandler, S., Johnson, M. H., & Charman, T. (2013). Failure to learn from feedback underlies word learning difficulties in toddlers at risk for autism. *Journal of Child Language*, *40*(01), 29–46. https://doi.org/10.1017/S0305000912000086

Bedford, R., Gliga, T., Shephard, E., Elsabbagh, M., Pickles, A., Charman, T., & Johnson, M. H. (2017). Neurocognitive and observational markers: Prediction of autism spectrum disorder from infancy to mid-childhood. *Molecular Autism*, *8*(1), 49. https://doi.org/10.1186/s13229-017-0167-3

Bent, C. A., Dissanayake, C., & Barbaro, J. (2015). Mapping the diagnosis of autism spectrum disorders in children aged under 7 years in Australia, 2010–2012. *The Medicinal Journal of Australia*, *202*(6), 317–320. https://doi.org/10.5694/mja14.003

Bernabei, P., Camaigni, L., & Levi, G. (1998). An evaluation of early development in children with autism and pervasive developmental disorders from home movies: Preliminary findings. *Autism*, *2*(3), 243–258. https://doi.org/10.1177/1362361398023003

Bishop, D. V. M. (2014). *Uncommon understanding*. Psychology Press.

Bloom, L., & Lahey, M. (1978). *Language development and language disorders*. Wiley & Sons.

Bopp, K. D., & Mirenda, D. P. (2011). Prelinguistic predictors of language development in children with autism spectrum disorders over four–five years. *Journal of Child Language*, *38*, 485–503. https://doi.org/10.1017/S0305000910000140

Bottema-Beutel, K. (2016). Associations between joint attention and language in autism spectrum disorder and typical development: A systematic review and meta-regression analysis. *Autism Research*, *9*(10), 1021–1035. https://doi.org/10.1002/aur.1624

Boucher, J. (2012). Research review: Structural language in autistic spectrum disorder - Characteristics and causes. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *53*(3), 219–233. https://doi.org/10.1111/j.1469-7610.2011.02508.x

Boyle, J., Gillham, B., & Smith, N. (1996). Screening for early language delay in the 18-36 month age-range: The predictive validity of tests of production, and implications for practice. *Child Language Teaching and Therapy*, *12*(2), 113–

127. https://doi.org/10.1177/026565909601200202

Brady, N. C., Marquis, J., Fleming, K., & McLean, L. (2004). Prelinguistic predictors of language growth in children with developmental disabilities. *Journal of Speech, Language and Hearing Research*, *47*(3), 663–677. https://doi.org/10.1044/1092-4388(2004/051

Brady, N. C., Thiemann-Bourque, K., Fleming, K., & Matthews, K. (2013). Predicting language outcomes for children learning augmentative and alternative communication: Child and environmental factors. *Journal of Speech, Language and Hearing Research*, *56*(5), 1595–1612. https://doi.org/10.1044/1092-4388(2013/12-0102

Brian, J., Bryson, S. E., Garon, N., Roberts, W., Smith, I. M., Szatmari, P., & Zwaigenbaum, L. (2008). Clinical assessment of autism in high-risk 18-month-olds. *Autism: The International Journal of Research and Practice*, *12*(5), 433–456. https://doi.org/10.1177/1362361308094500

Brignell, A. (2016). *Language development in autism spectrum disorder: Longitudinal comparison with a community cohort of children with language impairment and typical development*. [Doctoral Dissertation, The University of Melbourne].

Bruner, J., & Sherwood, V. (1983). Thought, language and interaction in infancy. In J. Call, E. Galeson, & R. Tyson (Eds.), *Frontiers of infant psychiatry* (pp. 38–55). Basic Books.

Bryson, S. E. (1996). Brief report: Epidemiology of autism. *Journal of Autism and Developmental Disorders*, *26*(2), 165–167. https://doi.org/10.1177/017084068800900203

Bryson, S. E., Zwaigenbaum, L., McDermott, C., Rombough, V., & Brian, J. (2008).

The Autism Observation Scale for Infants: Scale development and reliability data. *Journal of Autism and Developmental Disorders*, *38*(4), 731–738. https://doi.org/10.1007/s10803-007-0440-y

Butterworth, G., & Morissette, P. (1996). Onset of pointing and the acquisition of language in infancy. *Journal of Reproductive and Infant Psychology*, *14*(3), 219–231. https://doi.org/10.1080/02646839608404519

Calandrella, A. M., & Wilcox, M. J. (2000). Predicting language outcomes for young prelinguistic children with developmental delay. *Journal of Speech, Language and Hearing Research*, *43*(5), 1061–1067. https://doi.org/10.1177/017084068800900203

Carpenter, M., Nagell, K., Tomasello, M., Butterworth, G., & Moore, C. (1998). Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development*, *63*(4), 1–143. https://doi.org/10.2307/1166214

Charman, T., Baron-Cohen, S., Swettenham, J., Baird, G., Cox, A., & Drew, A. (2000). Testing joint attention, imitation, and play as infancy precursors to language and theory of mind. *Cognitive Development*, *15*(4), 481–498. https://doi.org/10.1016/S0885-2014(01)00037-5

Charman, T., Baron-Cohen, S., Swettenham, J., Baird, G., Drew, A., & Cox, A. (2003). Predicting language outcome in infants with autism and pervasive developmental disorder. *International Journal of Language and Communication Disorders*, *38*(3), 265–285. https://doi.org/10.1080/136820310000104830

Charman, T., Taylor, E., Drew, A., Cockerill, H., Brown, J. A., & Baird, G. (2005). Outcome at 7 years of children diagnosed with autism at age 2: Predictive validity of assessments conducted at 2 and 3 years of age and pattern of symptom change over time. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *46*(5), 500–513. https://doi.org/10.1111/j.1469-7610.2004.00377.x

Charman, T. (2003). Why is joint attention a pivotal skill in autism? *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *358*(1430), 315–324. https://doi.org/10.1098/rstb.2002.1199

Charman, T. (2004). Matching preschool children with autism spectrum disorders and comparison children for language ability: Methodological challenges. *Journal of Autism and Developmental Disorders*, *34*(1), 59–64. https://doi.org/10.1023/B:JADD.0000018075.77941.60

Charman, T, Drew, A., Baird, C., & Baird, G. (2003). Measuring early language development in preschool children with autism spectrum disorder using the MacArthur Communicative Development Inventory (Infant Form). *Journal of Child Language*, *30*(1), 213–236. https://doi.org/10.1017/S0305000902005482

Charman, T., Baird, G., Simonoff, E., Chandler, S., Davison-Jenkins, A., Sharma, A., O'Sullivan, T., & Pickles, A. (2016). Testing two screening instruments for autism spectrum disorder in UK community child health services. *Developmental Medicine and Child Neurology*, *58*(4), 369–375. https://doi.org/10.1111/dmcn.12874

Charman, T, & Stone, W. (Eds.). (2006). *Social & Communication Development in Autism Spectrum Disorders*. The Guildford Press.

Chawarska, K., Klin, A., Paul, R., Macari, S., & Volkmar, F. (2016). A prospective study of toddlers with ASD: Short-term diagnostic and cognitive outcomes. *Journal of Child Psychology and Psychiatry*, *50*(10), 1235–1245. https://doi.org/10.1111/j.1469-7610.2009.02101.x.A

Clifford, S., Young, R., & Williamson, P. (2007). Assessing the early characteristics of autistic disorder using video analysis. *Journal of Autism and Developmental Disorders*, *37*(2), 301–313. https://doi.org/10.1007/s10803-006-0160-8

Colgan, S. E., Lanter, E., McComish, C., Watson, L. R., Crais, E. R., & Baranek, G. T. (2006). Analysis of social interaction gestures in infants with autism. *Child Neuropsychology*, *12*(4–5), 307–319. https://doi.org/10.1080/09297040600701360

Colonnesi, C., Stams, G. J. J. M., Koster, I., & Noom, M. J. (2010). The relation between pointing and language development: A meta-analysis. *Developmental Review*, *30*(4), 352–366. https://doi.org/10.1016/j.dr.2010.10.001

Constantino, J. N., Zhang, Y., Frazier, T., Abbacchi, A. M., & Law, P. (2010). Sibling recurrence and the genetic epidemiology of autism. *American Journal of Psychiatry*, *167*(11), 1349–1356. https://doi.org/10.1176/appi.ajp.2010.09101470

Coster, F. W., Goorhuis-Brouwer, S. M., Nakken, H., & Spelberg, H. C. L. (1999). Specific language impairments and behavioural problems. *Folia Phoniatrica et Logopaedica*, *51*(3), 99–107. https://doi.org/10.1159/000021484

Crais, E. R., Watson, L. R., & Baranek, G. T. (2009). Use of gesture development in profiling children's prelinguistic communication skills. *American Journal of Speech-Language Pathology*, *18*(1), 95–108. https://doi.org/10.1044/1058-0360(2008/07-0041)

Crystal, D. (1995). *The Cambridge encyclopedia of the English language*. Cambridge University Press.

D'Souza, D., D'Souza, H., & Karmiloff-Smith, A. (2017). Precursors to language development in typically and atypically developing infants and toddlers: The importance of embracing complexity. *Journal of Child Language*, *44*(3), 591–627. https://doi.org/10.1017/S030500091700006X

Dawson, G., Toth, K., Abbott, R., Osterling, J., Munson, J., Estes, A., & Liaw, J. (2004). Early social attention impairments in autism: Social orienting, joint attention, and attention to distress. *Developmental Psychology*, *40*(2), 271–283. https://doi.org/10.1037/0012-1649.40.2.271

De Giacomo, A., & Fombonne, E. (1998). Parental recognition of developmental abnormalities in autism. *European Child and Adolescent Psychiatry*, *7*(3), 131–136. https://doi.org/10.1007/s007870050058

De Schuymer, L., De Groote, I., Striano, T., Stahl, D., & Roeyers, H. (2011). Dyadic and triadic skills in preterm and full term infants: A longitudinal study in the first year. *Infant Behavior and Development*, *34*(1), 179–188. https://doi.org/10.1016/j.infbeh.2010.12.007

Demouy, J., Plaza, M., Xavier, J., Ringeval, F., Chetouani, M., Périsse, D., Chauvin, D., Viaux, S., Golse, B., Cohen, D., & Robel, L. (2011). Differential language markers of pathology in Autism, Pervasive Developmental Disorder Not Otherwise Specified and Specific Language Impairment. *Research in Autism Spectrum Disorders*, *5*(4), 1402–1412. https://doi.org/10.1016/j.rasd.2011.01.026

DiStefano, C., Shih, W., Kaiser, A., Landa, R., & Kasari, C. (2016). Communication growth in minimally verbal children with ASD: The importance of interaction. *Autism Research*, *9*(10), 1093–1102. https://doi.org/10.1002/aur.1594

Donnellan, E., Bannard, C., McGillion, M. L., Slocombe, K. E., & Matthews, D. (2020). Infants' intentionally communicative vocalizations elicit responses from caregivers and are the best predictors of the transition to language: A longitudinal investigation of infants' vocalizations, gestures and word production. *Developmental Science*, *23*(1), 1–21. https://doi.org/10.1111/desc.12843

Drew, A., Baird, G., Baron-Cohen, S., Cox, A., Slonims, V., Wheelwright, S., Swettenham, J., Berry, B., & Charman, T. (2002). A pilot randomised control trial of a parent training intervention for pre-school children with autism: Preliminary findings and methodological challenges. *European Child and Adolescent Psychiatry*, *11*(6), 266–272. https://doi.org/10.1007/s00787-002-0299-6

Dunn, L. M., & Dunn, L. M. (1997). *Peabody Picture Vocabulary Test – Third Edition*. AGS Publishing.

Edwards, S., Letts, C., & Sinka, I. (2011). *The New Reynell Developmental Language Scales*. GL Assessment Limited.

Eimas, P. D., Siqueland, E. R., Jusczyk, P., & Vigorito, J. (1971). Speech perception in infants. *Science*, *171*(3968), 303–306. https://doi.org/10.1126/science.171.3968.303

Elsabbagh, M., Fernandes, J., Jane Webb, S., Dawson, G., Charman, T., & Johnson, M. H. (2013). Disengagement of visual attention in infancy is associated with emerging autism in toddlerhood. *Biological Psychiatry*, *74*(3), 189–194. https://doi.org/10.1016/j.biopsych.2012.11.030

Elsabbagh, M., & Johnson, M. H. (2010). Getting answers from babies about autism. *Trends in Cognitive Sciences*, *14*(2), 81–87. https://doi.org/10.1016/j.tics.2009.12.005

Feldman, H. M., Dale, P. S., Campbell, T. F., Colborn, D. K., Kurs-Lasky, M., Rockette, H. E., & Paradise, J. L. (2005). Concurrent and predictive validity of parent reports of child language at ages 2 and 3 years. *Child Development*, *76*(4), 856–868. https://doi.org/10.1111/j.1467-8624.2005.00882.x

Fenson, L., Dale, P. S., Reznick, J. S., Bates, E., Thal, D. J., Pethick, S. J., Tomasello, M., Mervis, C. B., & Stiles, J. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development*, *59*(5), 1–185. https://doi.org/10.2307/1166093

Fenson, L., Marchman, V. A., Thal, D. J., Dale, P. S., Reznick, J. S., & Bates, E. (2007). *MacArthur-Bates Communicative Development Inventories: User's guide and technical manual* (2nd ed.). Brookes Publishing.

Fernald, A., Perfos, A., & Marchman, V. A. (2006). Picking up speed and understanding: Speech processing efficiency and vocabulary growth across the 2nd year. *Developmental Psychology*, *42*(1), 98–116. https://doi.org/10.1037/0012-1649.42.1.98

Fuchs, D., Fuchs, L., Power, M., & Dailey, A. (1985). Bias in the assessment of handicapped children. *American Educational Research Journal*, *22*(2), 185–197. https://doi.org/10.3102/00028312022002185

Gillespie-Lynch, K., Sepeta, L., Wang, Y., Marshall, S., Gomez, L., Sigman, M., & Hutman, T. (2012). Early childhood predictors of the social competence of adults with autism. *Journal of Autism and Developmental Disorders*, *42*(2), 161–174. https://doi.org/10.1007/s10803-011-1222-0

Gliga, T., Bedford, R., Charman, T., Johnson, M. H., Baron-Cohen, S., Bolton, P., Cheung, C., Davies, K., Liew, M., Fernandes, J., Gammer, I., Maris, H., Salomone, E., Pasco, G., Pickles, A., Ribeiro, H., & Tucker, L. (2015). Enhanced visual search in infancy predicts emerging autism symptoms. *Current Biology*, *25*(13), 1727–1730. https://doi.org/https://doi.org/10.1016/j.cub.2015.05.011

Gliga, T., Elsabbagh, M., Hudry, K., Charman, T., & Johnson, M. (2012). Gaze following, gaze reading, and word learning in children at-risk for autism. *Child Development*, *83*(3), 926–938. https://doi.org/10.1111/j.1467-8624.2012.01750.x

Goldberg, M. C., Mostofsky, S. H., Cutting, L. E., Mahone, E. M., Astor, B. C., Denckla, M. B., & Landa, R. J. (2005). Subtle executive impairment in children with autism and children with ADHD. *Journal of Autism and Developmental Disorders*, *35*(3), 279–293. https://doi.org/10.1007/s10803-005-3291-4

Goldin-Meadow, S. (2007). Pointing sets the stage for learning language and creating language. *Child Development*, *78*(3), 741–745. https://doi.org/10.1111/j.1467-8624.2007.01029.x

Goldin-Meadow, S., Goodrich, W., Sauer, E., & Iverson, J. (2007). Young children use their hands to tell their mothers what to say. *Developmental Science*, *10*(6), 778–785. https://doi.org/10.1111/j.1467-7687.2007.00636.x

Goldstein, M. H., Schwade, J., Briesch, J., & Syal, S. (2010). Learning while babbling: Prelinguistic object-directed vocalizations indicate a readiness to learn. *Infancy*, *15*(4), 362–391. https://doi.org/10.1111/j.1532-7078.2009.00020.x

Golinkoff, R. M. (1986). 'I beg your pardon?': The preverbal negotiation of failed messages. *Journal of Child Language*, *13*(3), 455–476. https://doi.org/10.1017/S0305000900006826

Gomez, J. C., Sarria, E., & Tamarit, J. (1993). The comparative study of early communication and theories of mind: Ontogeny, phytogeny, and pathology. In S. Baron-Cohen, H. Tager-Flusberg, & D. J. Cohen (Eds.), *Understanding other minds: Perspectives from autism* (pp. 397–426). Oxford University Press.

Gotham, K., Risi, S., Pickles, A., & Lord, C. (2007). The autism diagnostic observation schedule: Revised algorithms for improved diagnostic validity. *Journal of Autism and Developmental Disorders*, *37*(4), 613–627. https://doi.org/10.1007/s10803-006-0280-1

Hahn, L. J., Hamrick, L. M., Kelleher, B. L., & Roberts, J. E. (2020). Autism spectrum disorder-associated behaviour in infants with down syndrome. *Journal of Health Science and Education*, *4*(2), 139–148. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7357991/

Happé, F., & Frith, U. (1996). The neuropsychology of autism. *Brain*, *119*(4), 1377–1400. https://doi.org/10.1093/brain/119.4.1377

Howlin, P., Goode, S., Hutton, J., & Rutter, M. (2004). Adult outcome for children with autism. *Journal of Child Psychology and Psychiatry*, *45*(2), 212–229. https://doi.org/10.1111/j.1469-7610.2004.00215.x

Hudry, K., Chandler, S., Bedford, R., Pasco, G., Gliga, T., Elsabbagh, M., Johnson, M. H., & Charman, T. (2014). Early language profiles in infants at high-risk for autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *44*(1), 154–167. https://doi.org/10.1007/s10803-013-1861-4

Iverson, J. M., & Thal, D. (1998). Communicative transitions: There's more to the hand than meets the eye. In A. M. Wetherby, S. F. Warren, & J. Reichle (Eds.), *Transitions in prelinguistic communication* (pp. 59–86). Paul H. Brookes.

Iverson, Jana M., & Goldin-Meadow, S. (2005). Gesture paves the way for language development. *Psychological Science*, *16*(5), 367–371. https://doi.org/10.1111/j.0956-7976.2005.01542.x

Jones, E. J. H., Gliga, T., Bedford, R., Charman, T., & Johnson, M. H. (2014). Developmental pathways to autism: A review of prospective studies of infants at risk. *Neuroscience and Biobehavioral Reviews*, *39*(100), 1–33. https://doi.org/10.1016/j.neubiorev.2013.12.001

Kasari, C., Sigman, M., Mundy, P., & Yirmiya, N. (1990). Affective sharing in the context of joint attention interactions of normal, autistic, and mentally retarded children. *Journal of Autism and Developmental Disorders*, *20*(1), 87–100.

https://doi.org/10.1007/BF02206859

Keen, D., Meadan, H., Brady, N. C., & Halle, J. W. (Eds.). (2016). *Prelinguistic and Minimally Verbal Communicators on the Autism Spectrum*. Springer. https://doi.org/10.1007/978-981-10-0713-2

Kevan, F. (2003). Challenging behaviour and communication difficulties. *British Journal of Learning Disabilities*, *31*(2), 75–80. https://doi.org/10.1046/j.1468-3156.2003.00226.x

Kjelgaard, M. M., & Tager-Flusberg, H. (2001). An investigation of language impairment in autism: Implications for genetic subgroups. *Language Cognition Processes*, *16*(2–3), 287–308. https://doi.org/10.1080/01690960042000058

Kleinman, J. M., Ventola, P. E., Pandey, J., Verbalis, A. D., Barton, M., Hodgson, S., Green, J., Dumont-Mathieu, T., Robins, D. L., & Fein, D. (2008). Diagnostic stability in very young children with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *38*(4), 606–615. https://doi.org/10.1007/s10803-007-0427-8

Klin, A. (1991). Young autistic children's listening preferences in regard to speech: A possible characterization of the symptom of social withdrawal. *Journal of Autism and Developmental Disorders*, *21*(1), 29–42. https://doi.org/10.1007/BF02206995

Klin, A., Jones, W., Schultz, R., Volkmar, F., & Cohen, D. (2002). Visual fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. *Archives of General Psychiatry*, *59*(9), 809–816. https://doi.org/10.1001/archpsyc.59.9.809

Koegel, L., Koegel, R., & Smith, A. (1997). Variables related to differences in standardized test outcomes for children with autism. *Journal of Autism and*

Developmental Disorders, *27*(3), 239–248. https://doi.org/10.1023/A

Kover, S. T., McDuffie, A., Hagerman, R. J., & Abbeduto, L. (2013). Receptive vocabulary in boys with autism spectrum disorder: Cross-sectional developmental trajectories sara. *Journal of Autism & Developmental Disorders*, *43*(11), 2696–2709. https://doi.org/10.1007/s10803-013-1823-x.Receptive

Kwok, E. Y. L., Brown, H. M., Smyth, R. E., & Oram Cardy, J. (2015). Meta-analysis of receptive and expressive language skills in autism spectrum disorder. *Research in Autism Spectrum Disorders*, *9*, 202–222. https://doi.org/10.1016/j.rasd.2014.10.008

Landa, R., & Garrett-Mayer, E. (2006). Development in infants with autism spectrum disorders: A prospective study. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *47*(6), 629–638. https://doi.org/10.1111/j.1469-7610.2006.01531.x

Landa, R. J., Gross, A. L., Stuart, E. A., & Faherty, A. (2013). Developmental Trajectories in Children With and Without Autism Spectrum Disorders: The First 3 Years. *Child Development*, *84*(2). https://doi.org/10.1111/j.1467-8624.2012.01870.x

Landa, R. J., Holman, K. C., & Garrett-Mayer, E. (2007). Social and communication development in toddlers with early and later diagnosis of autism spectrum disorders. *Archives of General Psychiatry*, *64*(7), 853–864. https://doi.org/10.1001/archpsyc.64.7.853

Leekam, S. R., & Ramsden, C. A. H. (2006). Dyadic orienting and joint attention in preschool children with autism. *Journal of Autism and Developmental Disorders*, *36*(2), 185–197. https://doi.org/10.1007/s10803-005-0054-1

Loomes, R., Hull, L., & Mandy, W. P. L. (2017). What is the male-to-female ratio in autism spectrum disorder? A systematic review and meta-analysis. *Journal of the American Academy of Child and Adolescent Psychiatry*, *56*(6), 466–474. https://doi.org/10.1016/j.jaac.2017.03.013

Lord, C., Shulman, C., & DiLavore, P. (2004). Regression and word loss in autistic spectrum disorders. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *45*(5), 936–955. https://doi.org/10.1111/j.1469-7610.2004.t01-1-00287.x

Luyster, R., Gotham, K., Guthrie, W., Coffing, M., Petrak, R., Pierce, K., Bishop, S., Esler, A., Hus, V., Oti, R., Richler, J., & Risi, S. (2008). The Autism Diagnostic Observation Schedule – Toddler Module: A new module of a standardized diagnostic measure for autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *39*(9), 1305–1320. https://doi.org/10.1007/s10803-009-0746-z

Luyster, R. J., Kadlec, M. B., Carter, A., & Tager-Flusberg, H. (2008). Language assessment and development in toddlers with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *38*(8), 1426–1438. https://doi.org/10.1007/s10803-007-0510-1

Magiati, I., Tay, X. W., & Howlin, P. (2014). Cognitive, language, social and behavioural outcomes in adults with autism spectrum disorders: A systematic review of longitudinal follow-up studies in adulthood. *Clinical Psychology Review*, *34*(1), 78–86. https://doi.org/10.1016/j.cpr.2013.11.002

Manwaring, S. S., Mead, D. L., Swineford, L., & Thurm, A. (2017). Modelling gesture use and early language development in autism spectrum disorder. *International Journal of Language and Communication Disorders*, *52*(5), 637–651. https://doi.org/10.1111/1460-6984.12308

Marlow, M., Servili, C., & Tomlinson, M. (2019). A review of screening tools for the identification of autism spectrum disorders and developmental delay in infants and young children: Recommendations for use in low- and middle-income countries. *Autism Research*, *12*(2), 176–199. https://doi.org/10.1002/aur.2033

Mastrogiuseppe, M., Capirci, O., Cuva, S., & Venuti, P. (2015). Gestural communication in children with autism spectrum disorders during mother-child interaction. *Autism*, *19*(4), 469–481. https://doi.org/10.1177/1362361314528390

Maye, J., Werker, J. F., & Gerken, L. (2002). Infant sensitivity to distributional information can affect phonetic discrimination. *Cognition*, *82*(3), B101–B111. https://doi.org/10.1016/S0010-0277(01)00157-3

McCann, J., & Peppé, S. (2003). Prosody in autism spectrum disorders: A critical review. *International Journal of Language and Communication Disorders*, *38*(4), 325–350. https://doi.org/10.1080/1368282031000154204

McCathren, R. B., Yoder, P. J., & Warren, S. F. (2000). Testing predictive validity of the communication composite of the Communication and Symbolic Behavior Scales. *Journal of Early Intervention*, *23*(1), 36–46. https://doi.org/10.1177/10538151000230010801

McDaniel, J., Yoder, P., & Watson, L. R. (2017). A Path Model of Expressive Vocabulary Skills in Initially Preverbal Preschool Children with Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders*, *47*(4), 947–960. https://doi.org/10.1007/s10803-016-3016-x

McDuffie, A., Yoder, P., & Stone, W. (2005). Prelinguistic predictors of vocabulary in young children with autism spectrum disorders. *Journal of Speech, Language, and Hearing Research*, *48*(5), 1080–1097. https://doi.org/10.1044/1092-4388(2005/075

McLaughlin, M. R. (2011). Speech and language delay in children. *American Family Physician*, *83*(10), 1183–1188.

Messinger, D., Young, G. S., Ozonoff, S., Dobkins, K., Carter, A., Zwaigenbaum, L., Landa, R. J., Charman, T., Stone, W. L., Constantino, J. N., Hutman, T., Carver, L. J., Bryson, S., Iverson, J. M., Strauss, M. S., Rogers, S. J., & Sigman, M. (2013). Beyond autism: A baby siblings research consortium study of high-risk children at three years of age. *Journal of the American Academy of Child and Adolescent Psychiatry*, *52*(3), 300–308. https://doi.org/10.1016/j.jaac.2012.12.011

Mitchell, S., Brian, J., Zwaigenbaum, L., Roberts, W., Szatmari, P., Smith, I., & Bryson, S. (2006). Early language and communication development of infants later diagnosed with autism spectrum disorder. *Journal of Developmental and Behavioral Pediatrics*, *27*(2), 69–78. https://doi.org/00004703-200604002-00004 [pii]

Mody, M., & Belliveau, J. W. (2013). Speech and language impairments in autism: Insights from behavior and neuroimaging. *North American Journal of Medicine and Science*, *5*(3), 157–161. https://doi.org/10.7156/v5i3p157

Morales, M., Mundy, P., Delgado, C. E. F., Yale, M., Messinger, D., Neal, R., & Schwartz, H. K. (2000). Responding to joint attention across the 6-through 24-month age period and early language acquisition. In *Journal of Applied Developmental Psychology* (Vol. 21, Issue 3, pp. 283–298). https://doi.org/Doi 10.1016/S0193-3973(99)00040-4

Morales, M., Mundy, P., Delgado, C. E. F., Yale, M., Neal, R., & Schwartz, H. K. (2000). Gaze following, temperament, and language development in 6-month-olds: A replication and extension. *Infant Behavior and Development*, *23*(2), 231–

236. https://doi.org/10.1016/S0163-6383(01)00038-8

Mullen, E. M. (1995). *Mullen Scales of Early Learning*. Circle Pines.

Mundy, P, & Gomes, A. (1998). Individual differences in joint attention skill development in the second year. *Infant Behavior and Development*, *21*, 468–482.

Mundy, P. (1995). Joint attention and social-emotional approach behavior in children with autism. *Development and Psychopathology*, *7*(1), 63. https://doi.org/10.1017/S0954579400006349

Mundy, P. (2018). A review of joint attention and social-cognitive brain systems in typical development and autism spectrum disorder. *European Journal of Neuroscience*, *47*(6), 497–514. https://doi.org/10.1111/ejn.13720

Mundy, P., & Crowson, M. (1997). Joint attention and early social communication: Implications for research on intervention with autism. *Journal of Autism and Developmental Disorders*, *27*(6), 653–676. https://doi.org/10.1023/a:1025802832021

Mundy, P., Delgado, C., Block, J., Venezia, M., Hogan, A., & Seibert, J. (2003). *Manual for early social communication scales (ESCS)*. Coral Gables. http://www.ucdmc.ucdavis.edu/mindinstitute/ourteam/faculty_staff/escs.pdf

Mundy, P., Sigman, M., Ungerer, J., & Sherman, T. (1987). Nonverbal communication and play correlates of language development in autistic children. *Journal of Autism and Developmental Disorders*, *17*(3), 349–364. https://doi.org/10.1007/BF01487065

Mundy, P., Sullivan, L., & Mastergeorge, A. M. (2009). A parallel and distributed-processing model of joint attention, social cognition and autism. *Autism Research*, *2*(1), 2–21. https://doi.org/10.1002/aur.61

Noens, I. L. J., & Berckelaer-Onnes, I. A. V. (2005). Captured by details: Sense-making, language and communication in autism. *Journal of Communication Disorders*, *38*(2), 123–141. https://doi.org/10.1016/j.jcomdis.2004.06.002

Norrelgen, F., Fernell, E., Eriksson, M., Hedvall, Å., Persson, C., Sjölin, M., Gillberg, C., & Kjellmer, L. (2015). Children with autism spectrum disorders who do not develop phrase speech in the preschool years. *Autism*, *19*(8), 934–943. https://doi.org/10.1177/1362361314556782

Osterling, J., & Dawson, G. (1994). Early recognition of children with autism: A study of first birthday home videotapes. *Journal of Autism and Developmental Disorders*, *24*(3), 247–257. https://doi.org/10.1007/BF02172225

Ozonoff, S., Williams, B. J., & Landa, R. (2005). Parental report of the early development of children with regressive autism: The delays-plus-regression phenotype. *Autism*, *9*(5), 461–486. https://doi.org/10.1177/1362361305057880

Ozonoff, S., Young, G. S., Carter, A., Messinger, D. S., Yirmiya, N., Zwaigenbaum, L., Bryson, S., Carver, L. J., Constantino, J. N., Dobkins, K., Hutman, T., Iverson, J. M., Landa, R., Rogers, S. J., Sigman, M., & Stone, W. L. (2011). Recurrence risk for autism spectrum disorders: A baby siblings research consortium study. *Padiatrics*, *128*(3), 489–495. https://doi.org/10.1542/peds.2010-2825

Pandey, J. (2007). The modified checklist for autism in toddlers (M-CHAT) sibling study: Are younger siblings representative of the general ASD population? [Doctoral Dissertation, University of Connecticut]. In *University of Connecticut Research Commons*. http://digitalcommons.uconn.edu/dissertations/AAI3279299

Parladé, M. V., & Iverson, J. M. (2015). The development of coordinated communication in infants at heightened risk for autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *45*(7), 2218–2234.

https://doi.org/10.1007/s10803-015-2391-z

Paul, R., Fuerst, Y., Ramsay, G., Chawarska, K., & Klin, A. (2011). Out of the Mouths of Babes: Vocal Production in Infant Siblings of Children with ASD. *Journal of Child Psychology & Psychiatry*, *52*(2), 588–598. https://doi.org/10.1038/jid.2014.371

Paul, R, Chawarska, K., Cicchetti, D. V., & Volkmar, F. (2008). Language Outcomes of Toddlers With Autism Spectrum Disorders: A Two Year Follow-up. *Autism Research*, *1*(2), 97–107. https://doi.org/10.1001/archneurol.2010.367.Smoking

Paul, Rhea, Norbury, C., & Gosse, C. (2018). Special considerations for special populations. In *Language Disorders from Infancy Through Adolescence* (pp. 102–147). https://doi.org/10.1016/b978-0-323-44234-3.00013-0

Pedersen, J. (1997). Behavioral aspects of infantile autism: An ethoiogical description. *European Child and Adolescent Psychiatry*, *6*(2), 96–106. https://doi.org/10.1007/BF00566672

Pickles, A., Anderson, D. K., & Lord, C. (2014). Heterogeneity and plasticity in the development of language: A 17-year follow-up of children referred early for possible autism. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *55*(12), 1354–1362. https://doi.org/10.1111/jcpp.12269

Pierce, K., Glatt, S. J., Liptak, G. S., & McIntyre, L. L. (2009). The power and promise of identifying autism early: Insights from the search for clinical and biological markers. *Annals of Clinical Psychiatry*, *21*(3), 132–147.

Pituch, K. A., & Stevens, J. P. (2016). *Applied multivariate statistics for the social sciences* (6th ed.). Routledge.

Poon, K. K., Watson, L. R., Baranek, G. T., & Poe, M. D. (2012). To what extent do joint attention, imitation, and object play behaviors in infancy predict later communication and intellectual functioning in ASD? *Journal of Autism and Developmental Disorders*, *42*(6), 1064–1074. https://doi.org/10.1007/s10803-011-1349-z

Ramos-Cabo, S., Vulchanov, V., & Vulchanova, M. (2019). Gesture and language trajectories in early development: An overview from the autism spectrum disorder perspective. *Frontiers in Psychology*, *10*(MAY). https://doi.org/10.3389/fpsyg.2019.01211

Reilly, S., Bavin, E. L., Bretherton, L., Conway, L., Eadie, P., Cini, E., Prior, M., Ukoumunne, O. C., & Wake, M. (2009). The Early Language in Victoria Study ELVS: A prospective, longitudinal study of communication skills and expressive vocabulary development at 8, 12 and 24 months. *International Journal of Speech-Language Pathology*, *11*(5), 344–357. https://doi.org/10.1080/17549500903147560

Reilly, S., Wake, M., Ukoumunne, O. C., Bavin, E., Prior, M., Cini, E., Conway, L., Eadie, P., & Bretherton, L. (2010). Predicting language outcomes at 4 years of age: Findings from early language in Victoria study. *Pediatrics*, *126*(6). https://doi.org/10.1542/peds.2010-0254

Rescorla, L. (2009). Age 17 language and reading outcomes in late-talking toddlers: Support for a dimensional perspective on language delay. *Journal of Speech Language and Hearing Research*, *52*(1), 16–30. https://doi.org/https://doi.org/10.1044/1092-4388(2008/07-0171)

Reynell, J., & Gruber, C. (1990). *Reynell Development Language Scales: U. S. Edition*. Western Psychological Services.

Rice, M. L., Taylor, C. L., & Zubrick, S. R. (2008). Language outcomes of 7-year-old children with or without a history of late language emergence at 24 months.

Journal of Speech, Language, and Hearing Research, *51*(2), 394–407. https://doi.org/10.1044/1092-4388(2008/029)

Rice, M. L., Warren, S. F., & Betz, S. K. (2005). Language symptoms of developmental language disorders: An overview of autism, Down syndrome, fragile X, specific language impairment, and Williams syndrome. *Applied Psycholinguistics*, *26*(1), 7–27. https://doi.org/10.1017.S0142716405050034

Rowe, M. L., & Goldin-Meadow, S. (2009). Early gesture selectively predicts later language learning. *Developmental Science*, *12*(1), 182–187. https://doi.org/10.1038/jid.2014.371

Rowe, M. L., Özçaliskan, S., & Goldin-Meadow, S. (2008). Learning words by hand: Gesture's role in predicting vocabulary development. *First Language*, *28*(2), 182–199. https://doi.org/10.1177/0142723707088310.Learning

Rozga, A., Hutman, T., Young, G. S., Rogers, S. J., Ozonoff, S., Dapretto, M., & Sigman, M. (2011). Behavioral profiles of affected and unaffected siblings of children with autism: Contribution of measures of mother-infant interaction and nonverbal communication. *Journal of Autism and Developmental Disorders*, *41*(3), 287–301. https://doi.org/10.1007/s10803-010-1051-6

Ruppert, D. (2006). Trimming and winsorization. In S. Kotz, N. Balakrishnan, C. Read, & B. Vidakovic (Eds.), *Encyclopedia of Statistical Sciences* (2nd ed, pp. 8765–8770). Wiley-Interscience.

Sacrey, L. A. R., Zwaigenbaum, L., Szatmari, P., Bryson, S., Georgiades, S., Brian, J., Smith, I. M., Vaillancourt, T., Garon, N., Roncadin, C., & Elsabbagh, M. (2017). Brief report: Characteristics of preschool children with ASD vary by ascertainment. *Journal of Autism and Developmental Disorders*, *47*(5), 1542–1550. https://doi.org/10.1007/s10803-017-3062-z

Salley, B., Sheinkopf, S. J., Neal-Beevers, A. R., Elena, J., Miller-loncar, C. L., Tronick, E., Linda, L., Shankaran, S., Bada, H., Bauer, C., Hammond, J., & Lester, B. M. (2016). Infants' early visual attention and social engagement as developmental precursors to joint attention. *Developmental Psychology*, *52*(11), 1721–1731. https://doi.org/doi:10.1037/dev0000205

Sameroff, A. J., & Fiese, B. H. (2000). Transactional regulation: The developmental ecology of early intervention. In J. P. Shonkoff & S. J. Meisels (Eds.), *Handbook of early childhood intervention* (2nd ed., pp. 135–159). Cambridge University Press. https://doi.org/10.1017/CBO9780511529320.009

Sandbank, M., Woynaroski, T., Watson, L. R., Gardner, E., Kaysili, B. K., & Yoder, P. (2017). Predicting intentional communication in preverbal preschoolers with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *47*(6). https://doi.org/10.1007/s10803-017-3052-1

Sauer, E., Levine, S. C., & Goldin-Meadow, S. (2010). Early gesture predicts language delay in children with pre- or perinatal brain lesions. *Child Development*, *81*(2), 528–539. https://doi.org/10.1111/j.1467-8624.2009.01413.x

Schoemann, A. M., Boulton, A. J., & Short, S. D. (2017). Determining Power and Sample Size for Simple and Complex Mediation Models. *Social Psychological and Personality Science*, *8*(4), 379–386. https://doi.org/10.1177/1948550617715068

Senju, A. (2013). Atypical development of spontaneous social cognition in autism spectrum disorders. *Brain and Development*, *35*(2), 96–101. https://doi.org/10.1016/j.braindev.2012.08.002

Shriberg, L. D., Mcsweeny, J. L., Volkmar, F. R., Paul, R., Mcsweeny, J. L., Klin, A. M., Cohen, D. J., & Volkmar, F. R. (2001). Speech and prosody characteristics of adolescents and adults with high-functioning autism and Asperger syndrome. *Journal of Speech, Language, and Hearing Research*, *44*, 1097–1115. http://www.ncbi.nlm.nih.gov/pubmed/11708530

Shula, C., & Penny, R. (2007). The Preschool Repetition Test: An evaluation of performance in typically developing and clinically referred children. *Journal of Speech, Language, and Hearing Research*, *50*(2), 429–443. https://doi.org/10.1044/1092-4388(2007/030)

Shulman, C., Bukai, O., & Sigal, T. (2001). Communicative intent in autism. In E. Schopler, N. Yirmiya, C. Shulman, & L. M. Marcus (Eds.), *The Research Basis for Autism Intervention* (pp. 117–133). Plenum Publishers. https://doi.org/10.1007/0-306-47946-x_9

Shumway, S., & Wetherby, A. (2009). Communicative acts of children with autism spectrum disorders in the second year of life. *Journal of Speech, Language and Hearing Research*, *52*(5), 1139–1156. https://doi.org/10.1044/1092-4388(2009/07-0280

Sigman, M., & McGovern, C. W. (2005). Improvement in cognitive and language skills from preschool to adolescence in autism. *Journal of Autism and Developmental Disorders*, *35*(1), 15–23. https://doi.org/10.1007/s10803-004-1027-5

Sigman, M., & Ruskin, E. (1999). *Continuity and change in the social competence of children with autism, down syndrome, and developmental delays*. John Wiley and Sons.

Siller, M., & Sigman, M. (2002). The behaviors of parents of children with autism predict the subsequent development of their children's communication. *Journal of Autism and Developmental Disorders*, *32*(2), 77–89.

https://doi.org/10.1023/a:1014884404276

Siller, M., & Sigman, M. (2008). Modeling longitudinal change in the language abilities of children with autism: Parent behaviors and child characteristics as predictors of change. *Developmental Psychology*, *44*(6), 1691–1704. https://doi.org/10.1037/a0013771

Slaughter, V., & McConnell, D. (2003). Emergence of joint attention: Relationships between gaze following, social referencing, imitation, and naming in infancy. *Journal of Genetic Psychology*, *164*(1), 54–71. https://doi.org/10.1080/00221320309597503

Smith, V., Mirenda, P., & Zaidman-Zait, A. (2007). Predictors of expressive vocabulary growth in children with autism. *Journal of Speech, Language, and Hearing Research*, *50*(1), 149–160. https://doi.org/10.1044/1092-4388(2007/013

Sparrow, S. S., Balla, D. A., & Cicchetti, D. V. (1984). *Vineland Adaptive Behavior Scales*. American Guidance Service.

Squires, J., Potter, L., & Bricker, D. (1999). *The ASQ user's guide for the ages & stages questionnaires: A parent-completed, child-monitoring system* (2nd ed.). Paul H. Brookes.

StataCorp. 2019. *Stata Statistical Software: Release 16*. College Station, TX: StataCorp LLC.

Stern, L. M., Connell, T. M., Lee, M., & Greenwood, G. (1995). The Adelaide preschool language unit: Results of follow-up. *Journal of Paediatrics and Child Health*, *31*(3), 207–212. https://doi.org/10.1111/j.1440-1754.1995.tb00787.x

Stone, W. L., McMahon, C. R., Yoder, P. J., & Walden, T. A. (2007). Early social-communicative and cognitive development of younger siblings of children with autism spectrum disorders. *Archives of Pediatrics & Adolescent Medicine*, *161*(4), 384–390. https://doi.org/10.1001/archpedi.161.4.384

Stone, W. L., Ousley, O. Y., Yoder, P. J., Hogan, K. L., Hepburn, S. L., Littleford, C., Dennis, K., & Mahn, K. (1997). Nonverbal communication in two- and three-year-old children with autism. *Journal of Autism and Developmental Disorders*, *27*(6), 677–696. https://doi.org/10.1023/A:1025854816091

Stone, W. L., & Yoder, P. J. (2001). Predicting spoken language level in children with autism spectrum disorders. *Autism*, *5*(4), 341–361.

Tabachnick, B., & Fidell, L. (2007). *Using multivariate statistics*. Pearson Education, Inc.

Tager-Flusberg, H. (2006). Defining language phenotypes in autism. *Clinical Neuroscience Research*, *6*, 219–224. https://doi.org/10.1016/j.cnr.2006.06.007

Tager-Flusberg, H., & Caronna, E. (2007). Language disorders: Autism and other pervasive developmental disorders. *Pediatric Clinics of North America*, *54*(3), 469–481. https://doi.org/10.1016/j.pcl.2007.02.011

Tager-Flusberg, H., Paul, R., & Lord, C. (2014). Language and Communication in Autism. In F. R. Volkmar, R. Paul, S. J. Rogers, & K. A. Pelphrey (Eds.), *Handbook of Autism and Pervasive Developmental Disorders* (pp. 335–364). John Wiley & Sons. https://doi.org/10.1002/9780470939345.ch12

Tager-Flusberg, H., Paul, R., Yoder, P., Rogers, S., Cooper, J., Landa, R., Lord, C., Paul, R., Rice, M., Stoel-Gammon, C., Wetherby, A., & Yoder, P. (2009). Defining spoken language benchmarks and selecting measures of expressive language development for young children with autism spectrum disorders. *Journal of Speech, Language, and Hearing Research*, *52*(3), 643–652. https://doi.org/10.1044/1092-4388(2009/08-0136

Thal, D., & Bates, E. (1988). Language and gesture in late talkers. *Journal of Speech* *and Hearing Research*, *31*(1), 115–123. https://doi.org/10.1044/jshr.3101.115

Thurm, A., Lord, C., Li-Ching, L., & Newschaffer, C. (2007). Predictors of language acquisition in preschool children with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *37*(9), 1721–1734. https://doi.org/10.1007/s10803-006-0300-1

Tomasello, M. (1995). Joint attention as social cognition. In C. Moore & P. Denham (Eds.), *Joint attention: Its origins and role in development* (pp. 103–130).

Tomasello, M, Carpenter, M., & Liszkowski, U. (2007). A new look at infant pointing. *Child Development*, *78*(3), 705–722. https://doi.org/10.1111/j.1467-8624.2007.01025.x

Tomasello, M, & Farrar, M. J. (1986). Joint attention and early language. *Child Development*, *57*(6), 1454–1463. https://doi.org/10.2307/1130423

Tomasello, Michael, Carpenter, M., & Liszkowski, U. (2007). A new look at infant intelligence. *Child Development*, *78*(3), 705–722.

Tomasello, Michael, & Mervis, C. B. (1994). The instrument is great, but measuring comprehension is still a problem. *Monographs of the Society for Research in Child Development*, *59*(5), 174–179. https://doi.org/10.1111/j.1540-5834.1994.tb00186.x

Travis, L. L., & Sigman, M. (2001). Communicative intentions and symbols in autism: Examining a case of altered development. In J. A. Burack, T. Charman, N. Yirmiya, & P. R. Zelazo (Eds.), *The development of autism: Perspectives from theory and research* (pp. 279–308). Lawrence Erlbaum Associates.

Tsao, F. M., Liu, H. M., & Kuhl, P. K. (2004). Speech perception in infancy predicts language development in the second year of life: A longitudinal study. *Child Development*, *75*(4), 1067–1084. https://doi.org/10.1111/j.1467-

8624.2004.00726.x

Turner-Brown, L. M., Baranek, G. T., Reznick, J. S., Watson, L. R., & Crais, E. R. (2013). The first year inventory: A longitudinal follow-up of 12-month-old to 3-year-old children. *Autism: The International Journal of Research and Practice*, *17*(5), 527–540. https://doi.org/10.1177/1362361312439633

Ukoumunne, O. C., Wake, M., Carlin, J., Bavin, E. L., Lum, J., Skeat, J., Williams, J., Conway, L., Cini, E., & Reilly, S. (2012). Profiles of language development in pre-school children: A longitudinal latent class analysis of data from the Early Language in Victoria Study. *Child: Care, Health and Development*, *38*(3), 341–349. https://doi.org/10.1111/j.1365-2214.2011.01234.x

Volden, J., Smith, I. M., Szatmari, P., Bryson, S., Fombonne, E., Mirenda, P., Roberts, W., Vaillancourt, T., Waddell, C., Zwaigenbaum, L., Georgiades, S., Duku, E., & Thompson, A. (2011). Using the preschool language scale, fourth edition to characterize language in preschoolers with autism spectrum disorders. *American Journal of Speech-Language Pathology*, *20*(3), 200–208. https://doi.org/10.1044/1058-0360(2011/10-0035)

Volterra, V., Bates, E., Benigni, L., Bretherton, I., & Camaioni, L. (1979). First words in language and action: A qualitative look. In E. Bates (Ed.), *The emergence of symbols: Cognition and communication in infancy* (pp. 141–180). Academic Press. https://doi.org/10.1016/B978-0-12-081540-1.50010-7

Watson, L. R., Crais, E. R., Baranek, G. T., Dykstra, J. R., & Wilson, K. P. (2013). Communicative gesture use in infants with and without autism: A retrospective home video study. *American Journal of Speech-Language Pathology*, *22*(1), 25–39. https://doi.org/10.1044/1058-0360(2012/11-0145)

Watt, N., Wetherby, A., & Shumway, S. (2006). Prelinguistic predictors of language outcome at 3 years of age. *Journal of Speech and Hearing Research*, *49*(6), 1224–1237. https://doi.org/doi:10.1044/1092-4388(2006/088)

Weismer, S. E., & Kover, S. T. (2015). Preschool language variation, growth, and predictors in children on the autism spectrum. *Journal of Child Psychology & Psychiatry*, *56*(12), 1327–1337. https://doi.org/10.1111/jcpp.12406

Weismer, Susan Ellis, Lord, C., & Esier, A. (2010). Early Language Patterns of Toddlers on the Autism Spectrum Compared to Toddlers with Developmental Delay. *Journal of Autism and Developmental Disorders*, *40*(10), 1259–1273. https://doi.org/10.1007/s10803-010-0983-1.Early

Werner, E., & Dawson, G. (2005). Validation of the phenomenon of autistic regression using home videotapes. *Archives of General Psychiatry*, *62*(8), 889–895. https://doi.org/10.1001/archpsyc.62.8.889

Wetherby, A. M. (1986). Ontogeny of communicative functions in autism. *Journal of Autism and Developmental Disorders*, *16*(3), 295–316. https://doi.org/10.1007/BF01531661

Wetherby, A. M. (2008). Understanding and measuring social communication in children with autism spectrum disorders. In T. Charman & W. Stone (Eds.), *Social and communication development in autism spectrum disorders: Early identification, diagnosis, and intervention* (pp. 3–32). Guildford Press.

Wetherby, A. M., & Prizant, B. M. (2002). *Communication and Symbolic Behavior Scales: Developmental Profile* (1st normed). Paul H Brookes.

Wetherby, A. M., Prizant, B. M., & Schuler, A. L. (2000). Understanding the nature of communication and language impairments. In A. M. Wetherby & B. M. Prizant (Eds.), *Autism spectrum disorders: A transactional perspective* (pp. 109–141). Paul H Brookes.

Wetherby, A. M., & Prutting, C. (1984). Profiles of communicative and cognitive-social abilities in autistic children. *Journal of Speech, Language, and Hearing Research*, *27*(3), 364–377. https://doi.org/10.1044/jshr.2703.364

Wetherby, A. M., Woods, J., Allen, L., Cleary, J., Dickinson, H., & Lord, C. (2004). Early indicators of autism spectrum disorders in the second year of life. *Journal of Autism and Developmental Disorders*, *34*(5), 473–493. https://doi.org/10.1007/s10803-004-2544-y

Whitehouse, A. J. O., Varcin, K. J., Alvares, G. A., Barbaro, J., Bent, C., Boutrus, M., Chetcuti, L., Cooper, M. N., Clark, A., Davidson, E., Dimov, S., Dissanayake, C., Doyle, J., Grant, M., Iacono, T., Maybery, M., Pillar, S., Renton, M., Rowbottam, C., … Hudry, K. (2019). Pre-emptive intervention versus treatment as usual for infants showing early behavioural risk signs of autism spectrum disorder: a single-blind, randomised controlled trial. *The Lancet Child and Adolescent Health*, *3*(9). https://doi.org/10.1016/S2352-4642(19)30184-1

Winder, B. M., Wozniak, R. H., Parladé, M. V., & Iverson, J. M. (2013). Spontaneous initiation of communication in infants at low and heightened risk for autism spectrum disorders. *Developmental Psychology*, *49*(10), 1931–1942. https://doi.org/10.1037/a0031061

Woodward, A. (2005). Infants' understanding of the actions involved in joint attention. In N. Eilan, C. Hoerl, T. McCormack, & J. Roessler (Eds.), *Joint attention: Communication and other minds* (pp. 110–128). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199245635.001.0001

Yirmiya, N., & Charman, T. (2010). The prodrome of autism: Early behavioral and biological signs, regression, peri- and post-natal development and genetics. *Journal of Child Psychology and Psychiatry*, *51*(4), 432–458.

https://doi.org/10.1111/j.1469-7610.2010.02214.x

Yoder, P. J., & Warren, S. F. (1999). Maternal responsivity mediates the relationship between prelinguistic intentional communication and later language. *Journal of Early Intervention*, *22*(2), 126–136. https://doi.org/10.1177/105381519902200205

Yoder, P., Watson, L. R., & Lambert, W. (2015). Value-added predictors of expressive and receptive language growth in initially nonverbal preschoolers with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *45*(5), 1254–1270. https://doi.org/10.1007/s10803-014-2286-4

Zwaigenbaum, L., Thurm, A., Stone, W., Baranek, G., Bryson, S., Iverson, J., Kau, A., Klin, A., Lord, C., Landa, R., Rogers, S., & Sigman, M. (2007). Studying the emergence of autism spectrum disorders in high-risk infants: Methodological and practical issues. *Journal of Autism and Developmental Disorders*, *37*, 466–480. https://doi.org/10.1007/s10803-006-0179-x