Infant and Child-Directed Speech Used with Infants and Children at Risk or Diagnosed with Autism Spectrum Disorder: a Scoping Review

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Abstract

Infants diagnosed with autism spectrum disorder (autism) have difficulty engaging in social communication and interactions with others and often experience language impairment. The use of infant-directed speech (IDS), which is the speech register used when interacting with infants, is associated with infant language and socio-communicative development. The aim of this study was twofold; the first aim was to scope the literature to determine if evidence exists for differences between the IDS caregivers use to infants at high-risk or those later diagnosed with autism, and the IDS typically spoken to neurotypical infants. The second aim was to investigate if any IDS characteristics used by caregivers of high-risk or diagnosed infant populations predicted language development. Twenty-six studies were included and provided evidence that high-risk and later diagnosed infants are exposed to similar amounts of IDS as their neurotypical peers. There is evidence, however, that the IDS used with high-risk and later diagnosed infants may comprise shorter utterances, more action-directing content, fewer questions, more attention bids, and more follow-in commenting. There is also evidence that more attention bids and follow-in commenting used to infants at high risk or those later diagnosed with autism were associated with better language abilities longitudinally.

Keywords Infant-directed speech · Autism spectrum disorder · High-risk infants · Communication · Child-directed speech

Early interactions with primary caregivers comprise the socio-communicative and language environment for young infants. Infants who are later diagnosed with autism spectrum disorder (autism) have atypical socio-communication and difficulties in early interactions with others and often experience impaired language development (Beurkens et al., 2013). Early interactions are mediated by infant-directed speech (IDS), which is the way that most speakers adjust their speech when interacting with infants. Furthermore, IDS facilitates infant socio-communicative and language development (Cristia,

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2013; Golinkoff et al., 2015). An investigation is therefore warranted into whether the use of IDS with infants who are at high-risk (HR) or later diagnosed with autism is different than what is typically observed in the IDS used with their neurotypical peers. Furthermore, the characteristics of IDS that are associated with or predictive of better language abilities in HR infants or those later diagnosed are needed to inform early intervention.

Infant-Directed Speech

IDS is the speech register used when interacting with infants. IDS has acoustic and linguistic characteristics that are different from adult-directed speech and occurs across many languages and cultures (for reviews, see Saint-Georges et al., 2013; Soderstrom, 2007). When compared to adult-directed speech, IDS generally involves (1) higher and more variable pitch (Fernald & Simon, 1984; Fernald et al., 1989), (2) more distinctive pitch contours (Fernald & Simon, 1984), (3) longer pauses between words and sentences (Fernald & Simon, 1984; Fisher & Tokura, 1995; Grieser & Kuhl, 1988), (4) possibly a slower speaking rate (Han, 2018; cf. Martin et al., 2016), and (5) possibly hyperarticulation of vowels (Hartman et al., 2017; Kalashnikova & Burnham, 2018). Studies comparing the linguistic characteristics of IDS and adult-directed speech have found that IDS includes fewer and shorter words (Fisher & Tokura, 1995; Grieser & Kuhl, 1988; Soderstrom et al., 2008), more questions (Soderstrom et al., 2008), more isolated words (Soderstrom et al., 2008), and frequent use of proper names (Durkin et al., 1982).

IDS is considered an important tool for teaching infants language and social competencies, for attracting and maintaining their attention, and for conveying affect (Cooper & Aslin, 1990; Cristia, 2013; Dunst et al., 2012; Fernald, 1985; Golinkoff et al., 2015; Zangl & Mills, 2007). In support of the didactic function of IDS, it has for example been observed that IDS enhances infants' memory of spoken words (Singh et al., 2009) and word segmentation on the basis of transitional probabilities (Thiessen et al., 2005). IDS may also support language development indirectly, because it attracts and maintains infants' attention, as evidenced by infants' increased looking times to IDS compared to adult-directed speech (Cooper & Aslin, 1990, for a meta-analysis, see Dunst et al., 2012) as well as increased neural activity (Zangl & Mills, 2007). This increased attention to IDS makes it more likely that infants follow an adult's gaze (Senju & Csibra, 2008), a critical referential cue for word learning (Fisher & Tokura, 1995; Gangopadhyay & Kaushanskaya, 2020), and may aid the formation of neural associations between words and referents (Zangl & Mills, 2007).

The (prosodic) modifications in IDS have also been hypothesized to convey an overall positive emotion (Fernald &

Kuhl, 1987; Stern et al., 1982). Infants recognize this, as they display greater affective responsiveness (e.g., smiling and laughing more) to IDS, which also makes them more attractive social partners (Santarcangelo & Dyer, 1988; Werker & McLeod, 1989). Moreover, infants' preference for IDS is contingent on the IDS being "happy" (Singh et al., 2002). Within the IDS register, parents use their prosody to differentiate between the emotions they aim to convey (Fernald, 1989; Katz et al., 1996; Papousek et al., 1991; Trainor et al., 2000), and parents differ in their prosody depending on the affective characteristics of their infant (Stern et al., 1982; Woolard et al., 2016). Moreover, speakers differentiate more effectively between their emotional messages in IDS compared to adult-directed speech (Fernald, 1989). Infants are sensitive to these affective cues within IDS, looking longer or smiling more often to approvals and positively valance IDS while looking for shorter times or displaying negative affect in response to prohibitive and negatively valance IDS (Fernald, 1993; Papoušek et al., 1990). Yet, although the emotional tone of IDS is well-established, a recent meta-analysis has highlighted the need for more empirical evidence about the (longitudinal) impact thereof on infants' development (Spinelli et al., 2017).

Because IDS creates a good environment for learning language, as well as for attentional and emotional development, it is not surprising that aspects of infants' input are associated with their individual concurrent as well as longitudinal linguistic outcomes. The first property of infants' input that is strongly predictive of their language outcomes is the amount of time their parents talk with them, as more infant-directed input is associated with infants' better concurrent and later language skills (Hart & Risley, 1995; Hurtado et al., 2008; Huttenlocher et al., 1991; Ramírez-Esparza et al., 2014).

When parents produce IDS with more IDS-like acoustics, this is positively related to their infant's language development. A recent meta-analysis by Spinelli et al. (2017) identified that typical IDS prosody (defined as a high pitch, larger pitch variability, and the presence of exaggerated contours) was associated with better pre-linguistic and, to a lesser extent, linguistic outcomes (prelinguistic: Gratier & Devouche, 2011; Masataka, 1992; Niwano & Sugai, 2002a, 2002b; linguistic: D'Odorico & Jacob, 2006; Walker, 2012; Vosoughi et al., 2010; Lyakso et al., 2014). More recent empirical work not only provides further evidence that pitch variability in IDS is associated with later language skills in atypically-developing children (Dilley et al., 2020) but also supports the meta-analytic conclusion by Spinelli et al. (2017) that maternal pitch height, as opposed to measures of pitch change, may be a weaker predictor of infant language outcomes. Moreover, there is increasing evidence that the extent to which parents articulate more clearly to their infant is predictive of their child's language outcomes (Dilley et al., 2020; Hartman et al., 2017; Kalashnikova & Burnham, 2018; Liu et al., 2003).

The relationship between the linguistic form and content of parental input and infant language development, as reviewed by Soderstrom (2007) and Bernstein-Ratner (2013), appears to be somewhat less straightforward than "more-IDS-like" is better. On the one hand, and in line with the observation that IDS typically consists of shorter and simpler utterances, the extent to which mothers from high SES reduce their mean length of utterances (MLU) in IDS predicts longitudinal outcomes (Murray et al., 1990) and overall less complex language benefits children's language development (Furrow et al., 1979). However, the relationship between simplicity and language development is itself a complex one, as better child language outcomes have also been related to parental speech with relatively long MLU (Hoff & Naigles, 2002) and more diverse or sophisticated vocabulary (Bornstein et al., 1998; Pan et al., 2005; Weizman & Snow, 2001). More consistent conclusions about the impact of linguistic form and content on infant language development have been reported with respect to questions and directives: Parents may be promoting their language development asking their children more yes/no questions (Furrow et al., 1979; Newport et al., 1977) or using directives that follow-in on the child's attention (Akhtar et al., 1991). Other types of directives, in contrast, hinder language development, presumably because they disrupt the child's engagement or attention (Akhtar et al., 1991; McCathren et al., 1995; Murray & Hornbaker, 1997; Newport et al., 1977).

Despite the large body of work suggesting that the amount, acoustic properties, and linguistic features of IDS predict infant language outcomes, the recent meta-analysis that focused on prosodic features has highlighted the need for more empirical evidence about the longitudinal impacts on infants' development (Spinelli et al., 2017). Furthermore, given the multitude of functions that IDS serves in the development of typically-developing infants, it is important to understand the impacts of IDS when one or both of the partners do not display typical language, attention, or socio-communication skills. A critical first question to ask is whether the early linguistic environment is different or modified for infants who have difficulty in these areas, such as infants who are showing early signs of autism? A further important question is how the speech that these infants hear relates to or predicts their language abilities?

Autism in Early Infancy

At the core of a diagnosis of autism are persistent difficulties in social communication and social interaction, and restrictive or repetitive patterns of behavior, interests, or activities (American Psychiatric Association, 2013). Delay in social communication and language is considered an early behavioral marker of autism (for a review, see Szatmari et al., 2016). Confirmed diagnosis of autism is usually given after the age of 3 years, as it is after this age that core symptoms can be reliably observed and other developmental delays or comorbid issues can be ruled out (Elsabbagh & Johnson, 2007). A reliable diagnosis of autism, however, can be made at around 14 months, and early signs in infants as young as 6-months-of-age are being investigated (Brian et al., 2008; Chawarska et al., 2013; Pierce et al., 2019). Studies have also investigated prodromal symptoms of autism in early infancy in order to identify risk and subsequent interventions to improve outcomes (Bryson et al., 2007).

Social communication is affected in autism, and it has been suggested that children with autism display specific impairments in social orienting, joint attention, and attention to the distress of others (Dawson et al., 1998; Osterling et al., 2002; Sigman et al., 1992). The socio-communicative impairments observed in infants with autism can affect interactions with others; infants who go on to receive a diagnosis have been observed to display less synchronous interactions with their parent (Yirmiya et al., 2006); and, generally speaking, the more severe the autism symptoms, the poorer the interaction quality (Beurkens et al., 2013). A meta-analysis of joint attention during interactions with autistic children and their later language abilities showed that the joint attention displayed by children with autism is related to their receptive language development (Bottema-Beutel, 2016). This meta-analysis highlighted the need to address joint attention during interactions to improve language abilities in autistic children. Similarly, another recent review and meta-analysis investigated parental-verbal-responsiveness to high-risk (HR) infants and children with autism (Edmunds et al., 2019). This review found that parental-verbal-responsiveness that was correlated with the child's communication and focus of attention was associated with later child language outcomes. In addition, parental-verbal-responsiveness to HR infants was found to be more variable compared to parental-verbal-responsiveness used by parents of typically developing infants. The review suggests that parental-verbal-responsiveness could be an important aspect of intervention for HR infants and children with autism. Both parental-verbal-responsiveness and IDS are similar in that caregivers' contingent use of IDS is a characteristic of quality interactions; however, IDS encompasses many other variables that contribute to infant language acquisition and social-communication (e.g., acoustic/prosodic as well as linguistic properties, see above section), in addition to the mere frequency of usage. To date, however, there has been no attempt to collate the findings from existing studies in order to understand how the IDS used with HR and later diagnosed infants compares to that of their typically-developing peers.

The purpose of this scoping review is to identify and summarize the existing literature investigating parental IDS use with infants who are HR or those later diagnosed with autism. Specifically, this paper seeks to (1) determine if HR and later diagnosed infants are exposed to differing amounts or characteristics of IDS than their typically developing peers and (2)

identify if there are characteristics of IDS used with these infants that are related to or predictive of language abilities. We hypothesize that HR infants and those later diagnosed will be exposed to quantitatively and qualitatively different IDS than their typically developing peers, likely involving fewer questions, more directive speech, and flatter intonation. We also hypothesize that more IDS, more varied pitch, and more questions will be predictive of better language abilities in HR infants and those later diagnosed with autism. This review will be the first to investigate the literature on IDS used with HR infants and infants later diagnosed with autism, which has implications for early detection of autism and intervention for the infants and their families. A scoping review methodology was chosen to capture the breadth of work in this area. This review will search and review the literature on the characteristics of parental IDS (including frequency of input, prosodic, and lexical characteristics) used with HR and later diagnosed infants, including comparative studies with typically developing peers. Because autism is most frequently diagnosed after 2-years-of-age and parents have been shown to use IDS that is developmentally- or experientially matched (i.e., in the case of hearing-impaired infants) to their infant rather than chronologically-matched (Bergeson et al., 2006; Newman et al., 2016), this scoping review will include young children (<4 years).

Method

The study follows the scoping review framework and reporting guidelines set out by Arksey and O'Malley (2005). We adopted a search strategy using the following methods: systematic searches in electronic databases, hand-searching relevant journals, and hand-searching reference lists of the selected papers

(see Fig. 1 for review process). Six databases were searched for relevant articles published up to April 2020 (no beginning date). The databases were EMBASE (n= 31), Medline (n= 19), PsycINFO (n=159), Scopus (n= 29), CINAHL (n= 26), and Informit Health (n= 0). We found 197 articles through the initial search, after 87 duplications were removed.

Identifying Relevant Studies

Inclusion criteria for the scoping review were broad in order to include as much literature that may be relevant as possible (see Table 1 for search terms); therefore, studies were included if they involved the following: (1) infant or young child populations (<4 years), (2) parent or adult speech and language directed toward the infant or child, and (3) infants or children that are identified as being HR (born preterm, at genetic risk, at familial risk) and/or later diagnosed with autism. Grey literature was also included (N=2). Studies were excluded that involved the following: (1) only child (i.e., not adult) speech, (2) adolescent and older child populations (4+ years), (3) risk for or diagnosis of developmental delay or intellectual disability without autism, (4) articles not written in English, and (5) intervention studies. Abstracts were independently screened for inclusion criteria by two of three investigators who were all completing a PhD program in psychology. Any disagreements regarding inclusion between the reviewers were resolved by a fourth independent investigator, who was an associate professor in psychology. Full-text articles were obtained for studies that the screening process identified as relevant to the scoping review, or whose relevance was unclear from the abstract alone.

Of the 197 studies that were screened against title and abstract, 102 were excluded (see Fig. 1). Ninety-five full-text articles were assessed for relevance, 69 were excluded for

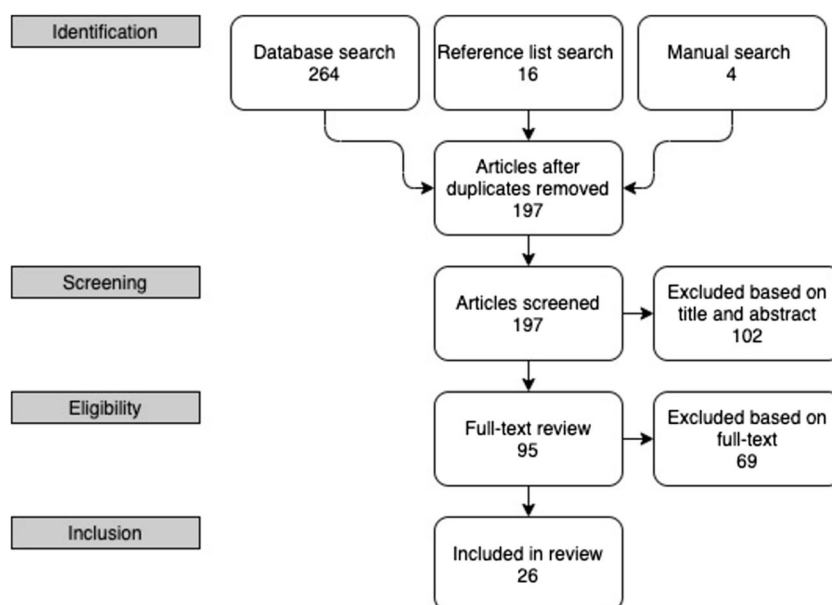Fig. 1 Article review and selection process

Table 1 Keywords used in database searches

Autism OR ASD OR Autism spectrum disorder OR Autistic disorder	AND: Diagnos* OR high-risk OR genetic risk OR familial risk OR autis* adj5^ symptom* OR autis* adj5† sign* OR autis* adj5 marker* OR autis* adj5 trait* OR autis* adj5 indicator* OR autis* adj5 precursor*	AND: Infant-directed speech OR Baby talk OR Child-directed speech OR motherese	AND: Child* OR infan* OR toddler* OR baby OR babies OR newborn*

† Adj5^ indicates a search run for 5 words adjacent to the key search term and only separated by a single space

various reasons including the child population being too old (*n*= 30), the study being an intervention design (*n*= 24), the article not being published in English and not translatable (*n*= 4), the infant/child speech rather than the parent speech being measured (*n*= 8), and developmental disorder/other disorder that is not autism (*n*= 3). Twenty-six studies were relevant to the scoping review and included in the final analysis. Qualitative analysis of the 26 studies revealed a number of common themes and constructs, which have been defined in Table 2. Data extraction followed PRISMA guidelines (Liberati et al., 2009).

Results

General Characteristics of Included Studies

A summary of key features and findings of the 26 studies included in the final review can be seen in Table 3. We

conducted a critical appraisal of the quality of the studies and their methodologies included in this review (see Table 4).

The age ranges for the infants and children included in the studies varied from birth to 4 years-of-age. As there was a range of ages included in the studies, we will refer to study participants aged between 0 and 12 months as "infants," and participants aged 13–48 months as "children."

Fifteen studies reported the native language of participants. American English/English was the most reported native language (*n*=9), followed by Irish English (*n*=2), French (*n*=2), Japanese (*n*=1), and Italian (*n*=1). One study also reported families that participated in the study were bilingual (French and English spoken at home; Kay-Raining Bird et al., 2008).

Twenty-two studies were conducted on infants later diagnosed with autism or children that had been diagnosed, and four studies compared HR/low-risk (LR) infants. Samples sizes of the studies varied, ranging from single-case studies to samples as large as 108 infants. Six of the studies looked at predictive relationships between the IDS used with HR infants

Table 2 Definitions of constructs within the studies included in the scoping review

IDS construct	Characteristics within construct	Definition
Amount of Speech/IDS	Amount of IDS	How much IDS is spoken by parents, The number of utterances spoken within a given time frame
Mean length of utterance		The mean length of an utterance (MLU) is the mean number of (usually) morphemes per utterance.
Questions used	*Wh* questions	Questions starting with "*wh*"-words, e.g., "what...?", "where...?" etc., which require a different response than "yes" or "no"
Content of IDS	Expansions	Expanding on the infant/child's utterances
	Information salient language	Information-salient speech is used to encourage exploration by the infant/child, which includes types of speech (e.g., direct statements, questions, or descriptions) and referents (to the environment, the child's actions or internal states, or the parent him/herself)
Complexity of language	Omission of determiners	Determiners (e.g., articles, possessive pronouns) omitted from noun phrases in which they were required by the grammatical rules of the language, e.g., "eat cookie" rather than "eat *the* cookie"
Acoustic features	F0/pitch	The highness or lowness of a tone as perceived by the ear, depending on the number of vibrations per second produced by the vocal cords
	Pitch contour	The trajectory of pitch over time, such as rising or falling
	Intensity	Vocal intensity of the speech (in decibel, dB)
Attentional features	Attention bids	Attempts to gain an infant's attention
	Follow-in comments	An utterance that contains linguistic information that would facilitate language learning, is non-directive, and matches the infant's focus of attention
	Repeats	Repetition of the speakers/infant/child's utterance or vocalization

Table 3 Overview of the results of each study in the scoping review (ordered alphabetically)

Study	Sample size	Child age	Language spoken	Diagnostic criteria	Measures	Relevant results	Effect size
Adamson et al. (2012)	108; 53 typically developing, 23 ASD, 29 Down syndrome	30 months (ASD and Down syndrome), 18 months (neurotypical)	American English	Autism Diagnostic Interview-Revised	- Style of verbal interaction - Follow-in comments	- Highlighted symbols more - Less supportive scaffolds - Effective communication heightened when requesting	- Effect sizes provided only for group differences in child's joint attention, not IDS differences
Adamson et al. (2015)	104; 56 Typically developing, 23 ASD, 29 Down syndrome	30 months (ASD and Down Syndrome infants), 18 months (typically developing infants)	American English	Autism Diagnostic Interview-Revised	- Amount of speech - Attention seeking behavior towards novel objects when presenting new words	- Parents of autistic children were more likely to attempt to gain attention before presenting the child with novel object and new word	- $\eta^2 = .050, p = .006$
Adamson et al. (2001)	18 (9 with ASD)	32 months (range 25–44)	American English	Autism Diagnostic Interview-Revised	- Attention-regulating bids	- Less communicative bids - Focused attention on shared objects or events without the use of words - Mothers used both literal and conventional attention-regulating bids (compared to conventional only for typically developing group)	- $\eta^2 = 0.18$ (communicative bids) - $\eta^2 = 0.64$ (focused attention) - $\eta^2 = 0.77$ (literal and conventional bids)
Bottema-Beutel et al. (2014)	63 ASD	24–47 months	Not specified	Autism Diagnostic Observation Schedule	- Parental higher- and lower-supported joint attention strategies - Follow-in utterances - Child language development (receptive and expressive) and social communication	- Higher-supported joint attention was predictive of expressive language and social communication - Follow-in utterances were predictive of receptive language and social communication	- R squared = 0.27 (expressive language) and 0.23 (social communication)
Brisson et al. (2014)	13 ASD, 13 Typically-developing	0–6 months	French	DSM-IV-TR criteria and the Childhood Autism Rating Scale	- Duration of IDS - Mean pitch of IDS	- Mothers utterances are shorter	- Effect size not reported
Cassel et al. (2014)	Case study, 2 (1 ASD, 1 typically developing) (one infant with ASD and one Typically-developing infant)	Longitudinal 0–18 months	Not specified	Autism Diagnostic Interview-Revised	- Caregiver solicitation and stimulation towards infant - Motherese production	- Mother of infants with ASD: - Higher and longer vocalization rate during semester 1 and 2, but not semester 3 - Rate of vocalizations decreased faster (between semesters 1 and 2) - Father of infants with ASD	- Effect size not reported

Table 3 (continued)

Study	Sample size	Child age	Language spoken	Diagnostic criteria	Measures	Relevant results	Effect size
Choi et al. (2020)	53 HR 33 LR	12, 18, 24 months	American English	Social Communication Questionnaire and Autism Diagnostic Observation Schedule	- Parental word tokens - Parental word types - Parental verbal responses - Parental MLU	- Lower rates of speech towards infant - Parents used similar word tokens - Parents used similar word types - Parents used the same proportion of verbal responses - Parents of HR used shorter MLU - MLU was positively associated with infant language 6-months after study visit	- $\eta^2 = 0.022, 0.008, 0.037$ (word tokens 12, 18, 24 months) - $\eta^2 = 0.005, 0.025, 0.068$ (word types 12, 18, 24 months) - $\eta^2 = .002, .020, .007$ (verbal responses 12, 18, 24 months) - $\eta^2 = 0.056, 0.209, 0.169$ (MLU 12, 18, 24 months)
Cohen et al. (2013)	15 ASD 15 typically developing	18 months	Not specified	Autism Diagnostic Interview Revised, Childhood Autism Rating Scale	- IDS use	- Fathers: - Used more IDS	- Effect size not reported
Doussard-Roosevelt et al. (2003)	24 ASD 24 typically developing	36-59 months	Not specified	Autism Diagnostic Interview Revised	- Social approaches	- Fewer social approaches - More physical contact	- Effect size not reported
Haebig et al. (2013a, b)	34 ASD	31.35 and 66.91 months	Not specified	Autism Diagnostic Interview Revised, Autism Diagnostic Observation Schedule	- Follow-in comments - Directives - Parent descriptions	- Follow-in comments predicted later language abilities - Redirective language was negatively associated with later language outcomes	- R squared = 0.20 (follow-in comments) - R squared = 0.14 (redirective language)
Haebig et al. (2013a, b)	40 ASD	24–39 months	American English	Autism Diagnostic Interview Revised, Autism Diagnostic Observation Schedule	- Verbal responses	- Follow-in comments were significantly related to better language outcomes (comprehension and production)	- R squared = 0.34 (comprehension) - R squared = 0.22 (production)
Jakubowski (2011)	11 HR 11 LR	36 months	English	Autism Diagnostic Observation Schedule	- Utterances - Attention buds - Directiveness - Labeling	- More attention directing speech - More utterances consisting of speech accompanied by salient nonverbal behaviors - Less object labeling than LR - Used more suggestive speech	- Effect sizes not reported
Kay-Raining Bird et al. (2008)	1 (case study, ASD)	44 months	French and English	An assessment done at a developmental assessment clinic	- Compared use of internal state language between mother and father	- Mother spoke more often - Mother used more internal state language than father - Sensory internal state language used most	- Effect sizes not reported

Table 3 (continued)

Study	Sample size	Child age	Language spoken	Diagnostic criteria	Measures	Relevant results	Effect size
						- Both parents spoke fewer utterances than what is shown for parents of neurotypical children - Parents used more internal state language than what has been observed in neurotypical children	- Effect sizes not reported
Leezenbaum et al. (2014)	12 (HR) 14 (LR)	13 and 18 months	American English	Autism Diagnostic Observation Schedule	- Maternal vocalisations	- Mothers of HR children produced higher proportions of translations in response to gives/requests at 13 months - Mothers of LR children increased verbal responses to infant vocalisations between the two time points, mothers of HR child did not	- Effect sizes not reported
McDuffie and Yoder (2010)	32 ASD	18–60 months	English	Autism Diagnostic Observation Schedule	- Responsiveness	- Expansions of child verbal utterances predicted child vocabulary scores - Number of utterances that followed into child's focus of attention, and responses to infant verbal utterances predicted change in spoken language	- R squared = 0.07 (vocabulary scores) - R squared = 0.14 (follow-in utterances), - R squared = 0.11 (responses)
Perryman et al. (2013)	37 ASD	21 months	Not specified	Autism Diagnostic Observation Schedule, parent interviews	- Follow-in comments	- Linguistic responsiveness was a predictor of early receptive language growth - Follow-in comments were associated with increases in receptive language	- R squared = 0.16 (responsiveness) - R squared = 0.39 (follow-in comments)
Quigley and McNally (2013)	10 LR 7 HR	3.7 months LR 5.2 months HR	Irish English	No diagnostic assessment, sibling with diagnosed ASD	- Utterances - Attention bids - Interrogatives - Responses	- Equal amount of utterances - Lower contingently responsive utterances - Higher rates of attention bids - Equal rates of questions	- Effect sizes not reported
Quigley et al. (2016)	10 HR 9 LR	12 and 18 months	Irish English	No diagnostic assessment, sibling assessed with Autism Diagnostic Observation Schedule	- Mean pitch - Pitch range - Vocal intensity dB	- Vocal intensity became more evident over time (rather than less with LR) - Increased mean pitch for HR, decreased mean pitch for LR	- η^2 = 0.21 (intensity) - η^2 = 0.23 (pitch)
Saint-Georges et al. (2011)	15 ASD 12 Intellectual disability 15 Typically-developing	6 months, 12 months, greater than 12 months	Not specified, from an Italian HM database	Autism Diagnostic Interview Revised	- Regulation of infant behavior - Touching - Gesture	- Found little difference in vocal responses - More regulation and touching	- Effect sizes not reported

Table 3 (continued)

Study	Sample size	Child age	Language spoken	Diagnostic criteria	Measures	Relevant results	Effect size
Shizawa et al. (2012)	Case study 2 (1 infant with ASD and 1 typically developing infant)	12 months	Japanese	Autism Diagnostic Observation Schedule	- Vocalization - Frequency of ostensive cues - Type of ostensive cues	- Mother of infants with ASD: - Used more ostensive cues - Used more infant-directed actions - Less name-calling - Less pointing - More visible and direct cues	- Effect sizes not reported
Talbott et al. (2016)	30 HR 30 LR	6–18 months	American English	Autism observation scale for infants	- Maternal responses - Maternal language	- More object labeling - More acknowledgements - No difference between language or non-language promoting vocalizations	- Effect sizes not reported
Trevarthen and Daniel (2005)	Case study of twins, one with ASD	11 months	Not specified	International classification of diseases, 10th revision	- Verbal and nonverbal behaviors in a game	- Less warmth to ASD twin - Less synchronous with ASD twin - Less rhythm with ASD twin	- Effect sizes not reported
Venuti et al. (2012)	20 typically developing 20 ASD 20 Down syndrome	24 months	Italian	Autism Diagnostic Observation Schedule	- Salient speech - Discouragement - Nonsense - Greetings - Mimic - Singing - Onomatopoeia - Conventions - Info salient speech	- More use of child's name - More controlling - More references to child's action - Language was more focused on orienting child's actions than on environment - Reference to themselves (mother) more - Same total amount of speech, reference to child state, and frequency of descriptive speech compared to mothers of typically-developing children	- Effect sizes not reported
Venker et al. (2015)	55 ASD	3.5–4.5 years	American English	Autism Diagnostic Observation Schedule, Autism Diagnostic Interview-Revised	- Parent speech	- Parents who used a higher rate of single words and determiner omissions in phrases had children with lower grammatical complexity and lexical diversity	- R squared = 0.16
Xu et al. (2012)	71 ASD 49 LD 106 typically developing	ASD- 60 months typically developing- 30 months	Not specified	Not reported	- Parental speech to toddlers vs adults	- Broader, more exaggerated prosodic characteristics - Greater vowel durations - Greater vocal intensity - Higher pitch - More non-speech sounds	- Effect sizes not reported
Yoder et al. (2015)	87 ASD	24–48 months	Not specified	Autism Diagnostic Observation Schedule	- Amount of parental responses	- The amount of parental linguistic responses were a predictor of expressive and receptive language growth	- R squared = 0.49 (expressive) and 0.26 (receptive)

or infants later diagnosed with autism and their language abilities.

The themes that emerged from the literature will be discussed in the following order: amount of speech/IDS and responses, acoustic features (pitch, pitch contours, intensity), mean length of utterances (MLU), content of IDS, use of questions, complexity of language, and attention-regulating features. Of the 26 studies included in this review, the most frequent outcome measures reported were attention-related speech (see Table 3).

Amount of Speech, IDS, and Responses

Seven studies investigating the amount of speech and/or the amount of IDS used by parents examined three outcomes: the amount of speech in general, the amount of IDS, and amount of responses to the child. Five studies found no difference in the amount of speech directed to children with autism compared to typically developing children (Choi et al., 2020; Cohen et al., 2013; Leezenbaum et al., 2014; Quigley & McNally, 2013; Talbott et al., 2016), and two others found mothers of children with autism spoke less (Cassel et al., 2014; Kay-Raining Bird et al., 2008).

Acoustic Features

Three studies assessed the acoustic features of IDS and language input with HR infants or children later diagnosed with autism (Brisson et al., 2014; Quigley et al., 2016; Xu et al., 2012). Brisson et al. (2014) found no difference in mean pitch or frequency of the different types of pitch contours used by mothers of infants later diagnosed with autism when compared with typically developing controls. Xu et al. (2012) found that mothers of autistic children spoke at a higher pitch and higher vocal intensity compared to mothers of developmentally-matched typically-developing peers. Similarly, Quigley et al. (2016) found that mothers of HR children had a wider pitch range than mothers of LR children. Moreover, the same study found that mothers of HR children increased their range of pitch when their child was between 12 and 18 months of age, compared to the typical decrease in pitch range that mothers of LR children displayed. The mothers of HR children also increased their vocal intensity from 12 months to 18 months of child age, compared to a decrease in vocal intensity for LR mothers.

Mean Length of Utterances

Two studies in the review reported on the mean length of utterances (MLUs) of caregivers of HR infants or those who had been later diagnosed with autism (Choi et al., 2020; Frank et al., 1976). Choi et al. (2020) found that parents of HR infants produced utterances with a lower MLU than parents

of LR infants. Similarly, Brisson et al. (2014) found that the mothers of infants later diagnosed used shorter utterances when interacting with their baby than mothers of typically developing infants.

Content: General Content

Three studies investigating the content of the IDS and language input provided by parents to their infants and children included elements such as the use of the child's name, information salient language, and language focused on directing the infant's actions. A study by Venuti et al. (2012), which compared maternal IDS spoken to children with autism, Down syndrome, and typically developing children, observed that mothers of children with autism used the child's name more often, used more information salient utterances, and referenced the child's actions more often than the other groups. One study on language content found no differences between parents of HR and LR infants in terms of language promoting (acknowledgements, imitations, labels) and non-language promoting (directive) vocalizations (Talbott et al., 2016). One case study found a father's speech towards his twin children to be more directive with his autistic child when compared with speech directed to his typically-developing child (Trevarthen & Daniel, 2005).

Content: Use of Questions

Venuti et al. (2012) compared autistic children and typically developing peers who were developmentally matched (~24–40 months) and found that mothers of autistic children used fewer questions than mothers of typically developing children.

Complexity of IDS and Language Input

One study by Venker et al. (2015) found that parents' rate of omission of obligatory determiners from noun phrases predicted their autistic child's language development: parents of autistic children who omitted more determiners had children with less developed language abilities one year later.

Attention-Regulating Characteristics

Ten of the studies included in this review investigated the content of speech directed towards children that specifically involved attention regulation, such as attention bids (Adamson et al., 2001, 2012, 2015; Bottema-Beutel et al., 2014; Haebig et al., 2013a, b; Jakubowski, 2011; McDuffie & Yoder, 2010; Perryman et al., 2013; Saint-Georges et al., 2011). It is of note that five of the studies in this area are predictive, focusing exclusively on children with autism and their later outcomes.

Table 4 Critical appraisal of the studies included in this review using an adaption of the Joanna Briggs critical appraisal checklist (JBI, 2020)

Study	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Adamson et al. (2012)	Y	Y	Y	Y	Y	Y	Y	Y	N/A	Y
Adamson et al. (2015)	Y	Y	Y	Y	Y	Y	Y	Y	N/A	Y
Adamson et al. (2001)	N	Y	Y	N	Y	Y	N/A	N/A	N/A	Y
Bottema-Beutel et al. (2014)	N/A	Y	Y	Y	Y	Y	Y	Y	Y	Y
Brisson et al. (2014)	N	Y	N	N	Y	Y	N/A	N/A	N/A	Y
Cassel et al. (2014)	N	Y	N	N	Y	Y	N/A	N/A	N/A	Y
Choi et al. (2020)	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cohen et al. (2013)	N	Y	N	N	Y	Y	Y	Y	Y	Y
Doussard-Roosevelt et al. (2003)	N	Y	N	N	Y	Y	N/A	N/A	N/A	Y
Haebig et al. (2013a, b)	N/A	Y	Y	Y	Y	Y	Y	Y	N	Y
Haebig et al. (2013a, b)	N/A	Y	Y	Y	Y	Y	Y	Y	N/A	Y
Jakubowski (2011)	Y	Y	N	N	Y	Y	N/A	N/A	N/A	Y
Kay-Raining Bird et al. (2008)	N/A	Y	N	N	Y	Y	N/A	N/A	N/A	Y
Leezenbaum et al. (2014)	Y	Y	N	N	Y	Y	Y	Y	N	Y
McDuffie and Yoder (2010)	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
Perryman et al. (2013)	N/A	Y	Y	Y	Y	Y	Y	Y	N	Y
Quigley and McNally (2013)	Y	Y	Y	Y	Y	Y	N/A	N/A	Y	Y
Quigley et al. (2016)	Y	Y	Y	Y	Y	Y	Y	Y	N/A	Y
Saint-Georges et al. (2011)	N	Y	N	N	Y	Y	Y	Y	Y	Y
Shizawa et al. (2012)	Y	Y	Y	Y	Y	Y	N/A	N/A	N/A	Y
Talbott et al. (2016)	N	Y	N	N	Y	Y	N/A	N/A	N/A	Y
Trevarthen and Daniel (2005)	N/A	Y	N	N	N	Y	N/A	N/A	N/A	Y
Venuti et al. (2012)	Y	Y	Y	Y	Y	Y	N/A	N/A	N/A	Y
Venker et al. (2015)	N/A	Y	N	N	Y	Y	Y	Y	Y	Y
Xu et al. (2012)	N/A	N	N	N	Y	Y	N/A	N/A	N/A	Y
Yoder et al. (2015)	N/A	Y	Y	Y	Y	Y	Y	Y	Y	Y

1. Were the two groups similar? (i.e., developmentally matched)

2. Were the study subjects and the setting described in detail?

3. Were confounding factors identified?

4. Were strategies to deal with confounding factors stated?

5. Were the groups/participants free of the outcome at the start of the study?

6. Were the outcomes measured in a valid and reliable way?

7. Was the follow up time reported and sufficient to be long enough for outcomes to occur?

8. Was follow up complete, and if not, were the reasons to loss to follow up described and explored? If not a follow-up study, were there procedures in place to account for any missing data?

9. Were strategies to address incomplete follow-up utilized?

10. Was appropriate statistical analysis used?

Of the ten studies exploring attention regulation, two focus on attention bids and seven on follow-in commenting (i.e., a comment on the infant's focus of attention). The number of attention bids was not found to be different between mothers of children with autism compared to mothers of typically developing children in one study (Adamson et al., 2001), while another study reported mothers of HR infants use more attention bids than mothers of LR infants (Jakubowski, 2011). Furthermore, Adamson et al. (2001) found that mothers of children with autism used a lower rate of bids that afforded shared commenting compared to the mothers of typically developing children. In terms of follow-in commenting, all five studies have found that parental use of follow-in commenting was associated with increases in receptive language or later language abilities (Bottema-Beutel et al., 2014; Haebig et al., 2013a, b; McDuffie & Yoder, 2010; Perryman et al., 2013).

The other two studies investigating attention-regulating characteristics looked at joint attention and attention-regulating vocal behaviors. One study found mothers and their children with autism have interactions involving less joint

attention (Adamson et al., 2012), and the authors later found these mothers were drawing their child's attention more before introducing a novel object when compared to the typically developing children or those with Down syndrome (Adamson et al., 2015). One study found mothers of infants later diagnosed with autism used more regulating vocal behaviors compared to mothers of typically developing infants (Saint-Georges et al., 2011).

General Discussion

This scoping review aimed to firstly determine if evidence exists suggesting HR infants, or infants later diagnosed with autism, are exposed to IDS that is qualitatively and quantitatively different to that of their typically developing peers. Secondly, this review aimed to determine if IDS used by caregivers to this population of infants was related to or predictive of better language abilities. After careful review of the 26 studies, we found no conclusive evidence that HR infants or infants later diagnosed with autism are exposed to different amounts of IDS, or IDS with different acoustic characteristics than typically developing infants and children. In fact, our review showed that HR infants or those later diagnosed with autism do not hear larger amounts of IDS or less exaggerated prosody, whereas the evidence was ambiguous as to whether they hear the same or smaller amounts of IDS input, or the same or more exaggerated prosody compared to their typically developing peers. However, there is some evidence that the characteristics of the IDS used with infants and children who are HR or later diagnosed may be different in several respects: it may contain shorter utterances, more content that directs the infants' actions, fewer questions, and more attention bids and follow-in commenting. The results of this scoping review also suggest that the use of more follow-in commenting is predictive of better language abilities, and greater omission of determiners is predictive of poorer language abilities, in those infants who are HR or later diagnosed with autism. In sum, these results suggest that the linguistic features of IDS used by caregivers with infants and children who are HR or later diagnosed with autism may be different and/or modified in the early years and may influence their language development. The findings of studies in this review also highlight that parents most likely adapt their speech to the developmental abilities of their child (Newman et al., 2016). As the studies we reviewed in this paper were conducted on a variety of ages, and the adaptations in IDS made by caregivers were found across ages, we argue that these IDS adaptations made extend beyond age. Moreover, because many of the findings in our study were from studies investigating infants' prior to diagnosis, the parents are likely not adapting to their child's diagnosis. Instead, it appears that parents are adapting their IDS to the child's linguistic or communicative abilities. It is therefore recommended that future

studies focus on implementing developmental age matching in their methodology when investigating parental IDS within the context of autism.

This review has highlighted various other ways to methodologically strengthen the investigation of caregiver IDS with HR infants and infants later diagnosed with autism. Firstly, the studies included in this review vary in the scope of their outcome measures, analyses, and populations, which may be related to the diverse findings. For example, studies varied in the native language of the study populations. For optimal interpretability across studies, it is recommended that future studies report the language spoken by participants (only 15 of the reviewed papers reported native language) and endeavor to replicate study findings in groups with different native languages. Future studies should also focus on investigating other languages not included in this review to ensure results are generalizable cross-culturally.

The studies presented also differed in terms of sample composition. Around half of the studies investigated diagnosed infants and children (Adamson et al., 2001, 2012, 2015; Haebig et al., 2013a, b; McDuffie & Yoder, 2010; Perryman et al., 2013; Shizawa et al., 2012), while the other half prospectively investigated HR infants and children (Jakubowski, 2011; Leezenbaum et al., 2014; Quigley & McNally, 2013). One further study used a retrospective design where home videos were used with infants and their families with no known risk and the autism diagnosis was made later in the infant's life (Saint-Georges et al., 2011). Although both prospective and retrospective investigation into autism populations have their respective benefits and shortcomings (for an overview, see Zwaigenbaum et al., 2007), there is little work directly assessing how each method contributes to our understanding of early autism. With respect to the study of IDS, studies with diagnosed children have the advantage that the results certainly concern input to children with autism. However, given that autism diagnoses typically occur after the child is 2 years of age, this approach cannot be used to gain insight into the features of caregivers' speech and language to younger children with autism. As prospective and retrospective studies each have their strengths and shortcomings, a combination may be best suited to fill this gap. For instance, prospective studies (i.e., studies on HR infants) specifically allow for fine-tuning the study design to the IDS characteristics of interest. Retrospective investigations (i.e., older home videos analyzed after infants have been diagnosed), on the other hand, provide a means of assessing input with infants that certainly go on to have an ASD diagnosis. As prospective studies are more frequently employed than retrospective investigations, it is critical that these studies continue to include whether infants go on to receive a diagnosis of autism (although 88% of studies in our review did report on this information).

A further issue with the sample composition of the studies in this review is that there were no attempts to relate IDS

characteristics to the severity of social communication or restricted and repetitive interests (two autism diagnostic criteria) that the HR infants and those later diagnosed displayed. As a result, it is currently impossible to know whether the observed heterogeneity in study findings is related to the autistic characteristics of the children, or, conversely, how different characteristics of autism shape caregivers' IDS. By more clearly describing the autistic populations included in future studies, we will begin to better understand the IDS used with HR infants or those later diagnosed with autism while taking into account the great diversity amongst children with autism. Such better sample descriptions will allow researchers and clinicians to identify more precisely (1) which elements of IDS are important or adapted for infants who are HR or later diagnosed with autism, and (2) which aspects of autism they are more clearly related to, which may assist in the development of targeted early interventions.

Finally, we note that only six studies have investigated predictive relationships between input and language outcomes in HR infants or those later diagnosed with autism, with five of these reporting on follow-in comments. As follow-in comments facilitate children's engagement and attention (McCathren et al., 1995), they are a reasonable first input feature to associate with the language outcomes of children who have difficulties engaging with and attending to others. However, the relationship between other aspects of children's input and their language outcomes remain under-researched. In particular, the lack of studies investigating the relationship between acoustic properties of the IDS and the language outcomes in HR infants or those later diagnosed with autism can be considered surprising: The prosodic properties of IDS play a key role in the attention regulation of neurotypical infants (Cooper & Aslin, 1990; Cristia, 2013; Dunst et al., 2012; Golinkoff et al., 2015; Zangl & Mills, 2007) and are associated with their language development (Spinelli et al., 2017). As such, prosodic modifications made in IDS may be particularly beneficial for children with autism, as many autistic children struggle with attention regulation (Chawarska et al., 2013). However, studies into the predictive relationship of prosodic modifications and language outcomes will need to be preceded by or conducted in conjunction with further baseline descriptions of the prosodic modifications in the input that these infants hear.

Completely absent from the current literature on acoustic properties of input to autistic children are studies on vowel hyperarticulation. As outlined above, many studies with neurotypical infants have demonstrated that caregivers hyperarticulate vowels in infant-directed speech (Kuhl, 2000). However, hyperarticulation is less prevalent in caregivers' speech to hearing-impaired infants (Lam & Kitamura, 2012) or infants at-risk for dyslexia (Kalashnikova et al., 2018), presumably in an unconscious response to the decreased language perception abilities of these children (Kalashnikova et al., 2018; Lam & Kitamura, 2012). Moreover, the degree of hyper-

articulation is related to language development in the neurotypical population, presumably because it facilitates the acquisition of clearly separated speech sound categories (Cristia & Seidl, 2014; Kuhl, 2000). It would therefore be of interest to investigate hyperarticulation in the IDS to HR infants and those later diagnosed with autism, as they too often display issues in language perception and processing (Boucher, 2003). Based on the literature with neurotypical infants as well as various special populations, one could expect that parents hyperarticulate less to HR infants and those later diagnosed with autism, but that the degree of hyperarticulation in the IDS to these children is positively related to their language outcomes.

Implications

An encouraging finding emanating from this scoping review is that several features of parental input to infants and children with autism were associated with language development in this population (Bottema-Beutel et al., 2014; Haebig et al., 2013a, b; McDuffie & Yoder, 2010; Perryman et al., 2013). In particular, follow-in commenting (related to responsivity during interactions) is suggested to positively predict language gains related to expressive and receptive language in infants with autism (Bottema-Beutel et al., 2014; Haebig et al., 2013a, b; McDuffie & Yoder, 2010; Perryman et al., 2013). All studies of follow-in commenting utilize a longitudinal design, suggesting that this type of design could also be fruitful for determining whether there are other predictors of language development within this population. One study did also find that parent's rate of omission of obligatory determiners from noun phrases predicted longitudinal language development (Venker et al., 2015), although the evidence for this association is weaker than the evidence for the association of follow-in commenting with language development given this association was based on only one study.

The evidence demonstrating that parents use more directive IDS with this population might be related to attention regulation, particularly as autistic children often struggle to maintain attention (Adamson et al., 2001). Directive language used by caregivers with HR or later diagnosed infants could be fruitful for early intervention *if* there is indeed a positive relationship with language outcomes. However, such a positive association would stand in contrast to what has been found in neurotypical populations where, typically, directives can hinder language development as they are thought to disrupt the infant's engagement or attention (Akhtar et al., 1991; McCathren et al., 1995; Murray & Hornbaker, 1997; Newport et al., 1977). Thus, the next step for this line of research would be to investigate the impact of caregivers' directive language on engagement and attention in HR infants and those later diagnosed as well as the associations between directive language and language outcomes in these populations. Future research could then determine under which circumstances, if any, there could

be a therapeutic benefit of directive language in parent-implemented interventions.

There is substantial evidence for the training of communication skills and parent encouragement of communication with older autistic children (e.g. the Early Start Denver Model) (Dawson et al., 2010), with significant improvements found for long-term language abilities (for a meta-analysis see Fuller et al., 2020). Research on such therapeutic benefits for intervention with infants, however, is scarce despite the need to intervene early (Green et al., 2010). IDS use by caregivers facilitates language and socio-communicative learning for young infants and is therefore an important avenue of research when considering young children showing early signs of autism. Understanding the early communicative context of autistic infants has important implications for clinical practice. Infants receive most language input in everyday situations, often involving parents. The findings of this scoping review, specifically that IDS characteristics used by caregivers of HR infants or those later diagnosed with autism may be associated with later language abilities, suggest that parent-implemented interventions shaping IDS use in the early years of life may provide the basis for promising early interventions. Further research is needed to determine if the IDS characteristics (such as follow-in commenting) that are associated with language outcomes can be utilized in early parent-infant interventions to enhance language outcomes in autistic populations. Improving the quality of parent-infant interactions is likely to not only improve the socio-communicative outcomes for the child but also provide parents with enhanced opportunities to connect and communicate in meaningful ways with their child. Parental education is an important area of intervention in autism (Green et al., 2010), and these studies in IDS (particularly those indicating IDS as predictive of later language abilities) highlight that caregivers should be encouraged and supported to provide a quality communicative learning environment for their children in order to give them the best outcome.

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