Delays in social communication are one of the most striking early markers of autism spectrum disorder (ASD; see Szatmari et al., 2016). Such precursors to ASD have been distinguished in a number of studies using the prospective ‘at-risk’ approach of studying the infant siblings of children already diagnosed, as they are at increased ASD risk (Ozonoff et al., 2011). However, much less is known about whether these emergent differences in social communication (as measured using standardised tests in interaction with a researcher) impact on how they interact with their regular social partners, which may in turn alter the interactive behaviour of their partners. Such perturbations are seen in the parent-infant interactions (PII) of other groups, such as young children with Down syndrome (Blacher et al., 2013; Slonims and McConachie, 2006), and over the long-term, logically affect the child’s social experience and opportunities.

As social and language development requires and is facilitated by social-communicative input and scaffolding that is consistent with sensitive and mutual interactions (Landry et al., 1997; National Institute of Child Health and Human Development (NICHD) Early Child Care Research Network, 2001; Page et al., 2010), early alterations in PII (such as reduced interaction from parents) are likely to have a cascade of effects ultimately affecting child social and communicative development (Sameroff, 2009). Conversely, this same pathway may open up opportunities for early intervention via PII ‘enrichment’ in this group (Brbashaw et al., 2015; Szatmari et al., 2016).

Longitudinal ‘at risk’ studies have successfully identified a range of early behavioural markers that delineate those high-risk (HR) infants later diagnosed with ASD from those who are not, as well as from ‘low risk’ (LR) infants with no family history of ASD (see Szatmari et al., 2016). However, while these studies have mostly used standardised and experimental tests, consideration of the child’s naturalistic environment is likely to be pertinent to our developmental understanding of early ASD emergence, and perhaps especially so if there is social neurodevelopmental vulnerability. Methodologically, social

Keywords
autistic spectrum disorders, developmental outcomes, high risk studies, parent–child interaction, parent–child relations
competence may be more accurately or sensitively reflected within PII as a more familiar and natural social context relative to experimental measures. Studying the infant’s behaviour within PII allows us to see in operation their social, relational and communicative tendencies (as opposed to skills competence per se) in dynamic transaction with the opportunities or constraints provided by primary caregivers.

In this systematic review, we synthesise at-risk studies that have measured PII at-risk or in emergent ASD in an attempt to identify a developmental timeline for PII in the first 2 years of life, in particular distinguishing (1) HR infants from LR infants and (2) HR infants later diagnosed with ASD from those who were not. Second, we reviewed from these studies any evidence for an association between PII and later social and communicative developmental outcomes, consistent with possible cascading effects of PII on subsequent development in the HR group.

**Methods**

**Search strategy and inclusion criteria**

In our systematic analysis of studies on PII in infants at familial risk of ASD, an electronic search of PsychINFO and PubMed databases included English-language peer-reviewed journals up to 10 April 2017 using the following keyword (or ‘title and/or abstract’) search terms: (autism OR autistic) AND infants AND risk AND (interaction OR synchrony OR respons* OR sensitivity OR play). The search yielded 498 articles (Figure 1). The abstracts of 351 articles (after duplicate removal) were manually screened independently by two reviewers (J.S., M.W.W.) for their potential in meeting the following inclusion criteria: (1) ASD risk design – A study of infants who have an older sibling with ASD, which includes at least one comparison group in the analysis (HR infants compared with LR controls, or HR infants with subsequent ASD (HR-ASD) compared with those with no ASD (HR-no ASD); (2) Measurement – An empirical observational study of relatively naturalistic interaction (i.e. in free play or face-to-face play, with or without toys) between infant and a primary caregiver; (3) Infant age < 24 months or, if unspecified, no older than the ‘18-month visit’.

The reference lists of the 25 articles were further searched, providing three additional papers which were screened to potentially meet criteria for inclusion. Regarding search reliability, reviewer agreement was 96%. The one disagreement was whether Talbott et al.’s (2016) study fulfilled the measurement eligibility criterion of free play; consensus agreement was to exclude as the paper combined data from two set-ups, of which book sharing was considered to be prespecified rather than free play interaction.
Of the 28 papers assessed, 16 met full inclusion criteria. Wan et al.’s (2012, 2013) papers involved largely the same sample and PII variables, so were treated as one study, resulting in 15 studies.

Coding procedures

The following information was extracted from the final 16 studies: publication source, sample characteristics (N in each group, age, N and age at diagnosis where relevant, ASD outcome criteria), PII characteristics (set-up/format, location, duration), PII measure characteristics (coding scheme, main variables measured and how), and results pertaining to PII effects by autism risk/outcome (HR vs LR, and/or HR-ASD vs HR-noASD) and statistical associations between a PII variable and later developmental outcomes in the full sample or by subgroup.

Results

Across the final 15 studies (Table 1), PII was observed in a total of 426 infants at familial risk of ASD (we include only the largest sample in this calculation if a different cohort was involved at each time point within a study). Most studies were cross-sectional. Of the six studies that repeated PII measurement, three captured individual longitudinal change. In total, 11 studies followed their HR sample up to full ASD or provisional diagnosis, of which 8 reported results by ASD outcome (i.e. HR-ASD, HR-noASD and LR). Samples sizes were a mean of 27.7 HR infants, with an infant age range of 5–18 months. PII set-ups varied between studies in location (home: six studies; lab: nine studies) and structure, including the kind of toys provided or allowed, positioning (e.g. floor play, face-to-face), and given instructions (though in most cases, caregivers were asked to play with their child as they would usually do at home). Interaction length varied (1–45 min), most commonly taking 5 min clips (six studies), and two studies analysed audio files only. Studies reported on infant (13 studies), parent (8 studies) and/or dyadic (5 studies) aspects of PII, and used microanalytic measures (12 studies), global rating measures (4 studies) or automatic acoustic analysis (1 study); 2 studies used more than 1 type. Five developmental areas were identified, the key findings of which are summarised below.

1. Caregiver and dyadic/interational qualities

Qualities of interaction in the dyad start to diverge possibly as early as 5 months as Yirmiya et al. (2006) reported that although synchrony among HR dyads was not more mother led than in LR dyads, coherence of synchrony was lower and tended to be below mid-range within interactions led by HR infants (Yirmiya et al., 2006). Of the two studies focused on both parent and infant PII variables in relation to later ASD, dyadic variables were found to predict ASD outcome, namely infant social reciprocity at 11–12 months (Campbell et al., 2015) and mutuality at 14 months (Wan et al., 2013). In Campbell et al. (2015), infant social reciprocity among the HR group, and not specific social behaviours as seen within interaction, predicted later severity of ASD markers (Campbell et al., 2015). In Wan et al. (2013), dyadic mutuality and two infant variables (attentiveness to parent, negative affect) predicted 3 year ASD status.

Two studies found that parents of HR infants are more directive towards their infants than parents of LR infants at 7 and 14 months (Wan et al., 2012, 2013) and at 9 months (Harker et al., 2016). Parent directiveness predicted slower growth in parent-directed smiles within PII from 9 to 18 months, while parental responsiveness predicted higher rates of concurrent parent-directed smiles (Harker et al., 2016). By contrast, parental responsiveness – both behavioural and emotional – remained remarkably unaffected among the HR group (Baker et al., 2010; Campbell et al., 2015; Wan et al., 2013). However, neither parent directiveness nor sensitive responsiveness predict ASD outcome (Wan et al., 2013).

2. Social communication

Delays in social communication become apparent towards the end of the first year. While parent-directed smiles usually decline sharply from 9 months, HR infants showed an increase (after controlling for maternal directiveness; Harker et al., 2016). This may reflect a HR group delay in the developmental shift from dyadic to triadic play interaction rather than increased positive affect or communication.

From 11 months, delays in the use of give and show gestures are seen among HR-ASD infants’ interactions (Campbell et al., 2015) and, from around 1 year, vocal delays are apparent in PII, as HR infants’ vocalisations tend to be less speech-like (Leezenbaum et al., 2014), less reminiscent of true babbling (Paul et al., 2011), and less often accompanied by gestures (Parladé and Iverson, 2015) than those of LR infants.

The amount that infants vocalised in the first year and that parents spoke, however, did not differ by risk status (Campbell et al., 2015; Northrup and Iverson, 2015; Parladé and Iverson, 2015; Rozga et al., 2011; Talbott et al., 2015). Furthermore, Talbott et al. (2015) reported no 12-month ASD outcome group differences in the proportions of gesture types used. Harder to explain is that Talbott et al. (2015) found that HR-ASD infants showed more different meanings conveyed through a gesture than did HR-noASD and LR infants at 12 months.

By the first half of the second year, HR delays in gesture frequency and sophistication are consistently found (Leezenbaum et al., 2014; Parladé and Iverson, 2015;
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<tr>
<td>Baker et al. (2010)</td>
<td>18-month visit: 24 HR, 9 LR N = 12 met DSM-IV-TR criteria (36months)</td>
<td>5-min lab-based free play with primary caregiver. G: Modified NICHD ECCN maternal sensitivity: responsiveness, respect for infant autonomy, positive regard for child, structuring, hostility.</td>
<td>Parent: ASD versus no-ASD (HR and LR combined): No group differences in maternal emotional supportiveness or structuring.</td>
<td>ASD infants: Maternal sensitivity was positively associated with later expressive language change and child behaviour. HR infants: Reciprocity and social behaviours (composite score) were negatively correlated with 36-month (mostly) symptom severity; low infant reciprocity uniquely predicted symptom severity.</td>
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<td>Harker et al. (2016)</td>
<td>9-month visit: 30 HR, 18 LR</td>
<td>5-min lab-based free play with mother. G: Maternal Behaviour Rating Scale-Revised (adapted): Maternal responsiveness, maternal directiveness. Microanalytic/ELAN Infant social smiles (rate): simultaneous eye contact and smiling to mother.</td>
<td>Infant: HR versus LR: Risk group did not predict social smile trajectory (9–18 months), but when taking maternal directiveness into account, HR infants showed greater growth in social smiling than did LR infants. Parent: HR &gt; LR more directive; no group difference in responsiveness. Dyad: Maternal directiveness predicted slower growth in social smiles overall, while responsiveness predicted higher rates of social smiles. Infant: HR versus LR: Points/shows increased in LR but not HR infants. LR only: Nonword vocalisation frequency decreased significantly between 13 and 18 months. Parent: HR versus LR: No overall differences in the proportion of responses to gestures. Of the infants who showed deictic gestures, ‘LR’ mothers responded with a higher proportion of verbal labels (13 and 18 months) while ‘HR’ mothers who showed both gesture types responded slightly more with verbal labels to gives/requests than points/shows at 13 months. Proportion of infant non-word vocalisations to which mothers responded verbally than did LR mothers. Whole sample: Maternal verbal labels in response to points/shows (but not gives/requests) at 13 months was positively associated with 18-month infant word production.</td>
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<td>Leezenbaurn et al. (2014)</td>
<td>13- and 18-month visits: 12 HR, 14 LR None met DSM-IV-TR criteria (36months)</td>
<td>45-min home-based interaction, with middle 15-min floor play with mother and favourite toys. M: Noldus: Infant mother-directed vocalisations: non-word, word; deictic gestures: request/give, point/show. Maternal verbal response, and whether translated (verbally labelled).</td>
<td>Infant: HR versus LR: Points/shows increased in LR but not HR infants. LR only: Nonword vocalisation frequency decreased significantly between 13 and 18 months. Parent: HR versus LR: No overall differences in the proportion of responses to gestures. Of the infants who showed deictic gestures, ‘LR’ mothers responded with a higher proportion of verbal labels (13 and 18 months) while ‘HR’ mothers who showed both gesture types responded slightly more with verbal labels to gives/requests than points/shows at 13 months. Proportion of infant non-word vocalisations to which mothers responded verbally than did LR mothers. Whole sample: Maternal verbal labels in response to points/shows (but not gives/requests) at 13 months was positively associated with 18-month infant word production.</td>
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<td>Mulligan and White (2012)</td>
<td>13 HR: 12.6 months; 12 LR: 12.1 months. N = 4 met unspecified ASD criteria (30months); not analysed separately</td>
<td>10-min home-based play with caregiver. M: Presence of sensory and motor behaviours (30-sec time samples): stereotypies; mouthing objects; movement transition; responses to visual, auditory and tactile stimuli; object manipulation; types of play</td>
<td>Infant: HR versus LR: HR infants moved around less and showed fewer object manipulations. No differences were found in any sensory or play behaviours (none were social play).</td>
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<td>Northrup and Iverson (2015)</td>
<td>9-month visit: 25 HR, 10 LR N = 3 met clinical ASD criteria; not analysed separately</td>
<td>5-min home-based floor play with mother and favourite toys. M: ELAN: Mother and infant vocalisations, intrapersonal pauses, latency to respond, simultaneous speech</td>
<td>Infant: HR versus LR: No group differences in vocalisation frequency, intrapersonal pause duration, latency to respond duration or variability, or percentage of simultaneous speech. Infant latency to respond duration predicted mother latency to respond duration but was not moderated by risk status. Parent: HR versus LR: No group differences in vocalisation frequency, intrapersonal pause duration, latency to respond duration or variability, or percentage of simultaneous speech.</td>
<td>Whole sample: Infant simultaneous speech (proportion of infant interruptions when mother vocalised) at 9 months positively predicted ‘language delay’ group status at 18–36 months (which included 3 HR-ASD and 10 HR-noASD infants)</td>
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<td>Parladé and Iverson (2015)</td>
<td>8, 10, 12, 14 and 18-month visit: 50 HR, 30 LR, N = 9 met DSM-TR criteria (36 months)</td>
<td>15-min home-based naturalistic observation with caregivers in normal activities; 10-min free floor play with primary caregiver. M: Noldus: Infant-initiated behaviours: caregiver-directed gestures, vocal utterances, eye gaze, smiles Coordinated communication bouts (2+ of above behaviours occurring simultaneously) and type (developmentally prior or developmentally advanced)</td>
<td>Infant: HR-ASD versus HR-noASD versus LR versus HR-LD: HR-ASD group showed almost no growth in communicative bouts; HR-ASD &lt; LR = HR-noASD = HR-LD by 12 months. HR-ASD group showed slower growth in gesture + non-word vocalisation/words combinations than the LR group but did not differ significantly from the other HR groups. HR-ASD and HR-LD infants showed low initial rates of gesture + non-word vocalisations/words, while HR-ASD continued to show comparatively low rates at 8 to 18 months. No group differences in social smile or directed vocalisation rates.</td>
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<td>Paul et al. (2011)</td>
<td>Cross-sectional data: 6 months: 28 HR, 20 LR; 9 months: 37 HR, 29 LR; 12 months: 38 HR, 31 LR N = 14 provisional diagnosis (24 months)</td>
<td>5-min lab-based free play with parent (the first 50 speech-like vocalisations coded). M (audio only): Vocalisation frequency, consonant types used, canonical syllables (indicative of true babbling), non-speech production: delight, distress, atypical</td>
<td>Infant: HR versus LR: No group differences in total vocalisations. HR infants produced fewer speech-like vocalisations at all time points, which increased dramatically between 6 and 12 months in LR infants, but not in HR infants. Proportion of non-speech productions was higher in HR infants by 12 months. Proportion of canonical syllables and consonant frequency was significantly lower at 9 months in the HR group. Infant: HR-ASD versus HR-noASD: HR-ASD infants produced fewer middle consonant types (6 months), fewer late consonant types (9 months), and fewer consonant types (12 months). Vocal production at 6 months not associated with concurrent cognitive functioning. Number of early consonants at six months produced was positively associated with expressive language and fine motor skill at 12 months.</td>
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<td>Quigley et al. (2016)</td>
<td>10 HR, 9 LR 12 months: 1.2/1.0 months; 18 months: 1.8/1.0 months</td>
<td>Up to 20 mins of home-based face-to-face interaction with mother. Automated acoustic analysis of audio data: Mother and infant prosody: pitch mean, range, intensity. Prosodic matching</td>
<td>Infant: HR versus LR: No significant differences in any vocal characteristics, except that pitch range was slightly but not significantly higher at 12 and 18 months in HR infants. Parent: HR versus LR: Mean pitch increased from 12 to 18 months in the HR group and decreased in the LR group. Vocalisation intensity also increased in the HR mothers (p = 0.056). The HR group’s higher pitch range was not significant. Dyad: LR dyads show 12 month prosodic matching in pitch range and intensity, but not HR dyads. HR dyads match in pitch mean at 18 months but not LR dyads.</td>
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<td>Rozga et al. (2011)</td>
<td>49 HR (ASD: 6.3 months; noASD: 6.1 months), 35 LR: (6.2 months) N = 8 met DSM-IV criteria (mostly 36 months)</td>
<td>1-min lab-based face-to-face interaction with mother. M: Onset and offset of gaze to mother’s face, smile, non-distress vocalisation and combinations (social smile, social vocalisation), converted to rates per minute and percentage durations</td>
<td>Infant: HR-ASD versus HR-noASD versus LR: Group status did not predict rates of, or proportion of total duration in, gaze to mother’s face, social smiles or social vocalisations.</td>
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### Table 1. (Continued)

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<td>Talbott et al. (2015)</td>
<td>12 month visit: 47 HR, 27 LR N = 9 met criteria at 36 months (n = 6) or 18/24 months</td>
<td>8-min lab-based free play with caregiver (infant gestures from this combined with an experimenter-led measure). M: Noldus: Parent and infant gestures: Deictic, conventional, representative; number of meanings conveyed through each (e.g. number of referents). M: Systematic Analysis of Language Transcripts software: Parent number of different words (vocabulary); total words (communicativeness)</td>
<td>Infant: HR-ASD versus HR-noASD versus LR: The composite score of the number of meanings conveyed through gesture (‘tokens’) was significantly lower in the HR-ASD group. No other group differences were found in infant language or gesture. Parent: HR-noASD &gt; HR-ASD = LR: Produced more gestures and more different meanings conveyed through gesture, but no difference in proportions of gesture types. ASD infants: Infant gesture use was positively associated with 18-month language. LR and no-ASD groups: Maternal gesture use was positively associated with 18 month language.</td>
<td>ASD infants: Infant gesture use was positively associated with 18-month language. LR and no-ASD groups: Maternal gesture use was positively associated with 18 month language.</td>
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<td>Wan et al. (2012, 2013)</td>
<td>6–10 months (mean 7 months): 45 HR, 47 LR; 12–15 months (mean 14 months): 43 HR, 48 LR N = 14 met DSM-IV criteria (36 months)</td>
<td>6-min lab-based free play with parent. G: Manchester Assessment of Caregiver-Infant Interaction Parent: Sensitive responsiveness, nondirectiveness; Infant: Attentiveness to parent, positive affect, liveliness; Dyad mutuality, engagement intensity</td>
<td>Infant: HR-ASD &lt; HR-noASD = LR: Liveliness at 7 months (not 14 months) and attentiveness to parent at 14 months (not 7 months). HR-ASD versus HR-noASD: 14 month ‘Infant positive/negative affect’ and ‘infant attentiveness to caregiver’ predicted 36-month ASD, independent of earlier atypicalities and infant age. Parent: HR &lt; LR in parent nondirectiveness at 7 months, with a trend in sensitive responsiveness after adjusting for infant age and non-verbal development. Parent variables did not predict 36-month ASD. Dyad: HR-ASD &lt; HR-noASD = LR: 14-month mutuality and intensity of engagement. Further, 14-month mutuality predicted 36-month ASD, independent of earlier ASD-related atypicalities and infant age.</td>
<td>ASD infants: Infant gesture use was positively associated with 18-month language. LR and no-ASD groups: Maternal gesture use was positively associated with 18 month language.</td>
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<td>Winder et al. (2013)</td>
<td>13 and 18 months: 15 HR 15 LR N = 3 met DSM-IV-TR criteria (36 months)</td>
<td>45-min home-based interaction: middle 15 min with caregiver; remainder without caregiver necessarily initiating interaction. M: Noldus: Infant words, non-word vocalisations, affective/other vocalisations. Gestures: Deictic (e.g. reach/request), representational (represent specific referents; e.g. ‘bye-bye’ = departure). Gesture–speech combinations.</td>
<td>Infant: HR versus LR: HR infants were less spontaneously communicative (although parents in both groups were similarly vocal) and produced lower rates of: communicative non-word vocalisations and words at 13 and 18 months, deictic gestures, specifically in the production in show and point gestures at 13 months (n.s. in reach and request), and 2 combination types (gesture and vocalisation; gesture and word) at 18 months. No group difference in the number of gesture combination types. Infant: HR-ASD versus HR-noASD: ASD infants (n = 3) initiated communication at a far lower rate, with no words, few communicative vocalisations and few combinations.</td>
<td>ASD infants: Infant gesture use was positively associated with 18-month language. LR and no-ASD groups: Maternal gesture use was positively associated with 18 month language.</td>
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<td>Yirmiya et al. (2006)</td>
<td>21 HR (mean 20.2 weeks), 21 LR (mean 19.7 weeks)</td>
<td>5-min lab-based interaction with mother without toys. M: Monadic Phase Manual (adapted): Mother or infant avert, object attend, social (e.g. reach, object play, social play. Infant protest. Synchrony: mother–infant cross-correlation in the above behaviours. Synchrony classified as infant led, mother led or mutual. Coherence of synchrony: shared variance of mother and infant behaviours (takes into account lag time).</td>
<td>HR versus LR: Synchrony type did not differ between groups, but coherence was lower in the HR group in infant-led interaction; significantly more HR infants had below mid-range coherence scores. Synchrony was not associated with 14 month cognition, language or non-verbal communication.</td>
<td>ASD infants: Infant gesture use was positively associated with 18-month language. LR and no-ASD groups: Maternal gesture use was positively associated with 18 month language.</td>
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Talbott et al., 2015; Winder et al., 2013) and is most marked in those with an eventual diagnosis of ASD (Parladé and Iverson, 2015; Talbott et al., 2015). As HR infants head towards 18 months, longitudinal studies reveal that they were slower to adopt combined vocal-gesture communication (Parladé and Iverson, 2015) and to decrease production of non-word vocalisations (Leezenbaum et al., 2014).

HR delays in the integration of infant gestures use did not necessarily adversely affect parental interactions (Campbell et al., 2015; Leezenbaum et al., 2014). Preliminary evidence raises the suggestion that parents may even use compensatory strategies in response to (knowledge of) their infant’s risk and/or emerging language difficulties by increasing their verbal labelling of infant give/request gesture referents at 13 and 18 months (Leezenbaum et al., 2014). Furthermore, Talbott et al. (2015) reported that mothers of HR-noASD infants produced significantly more gestures, and significantly more different meanings conveyed through gesture when their infant was 12 months old than mothers of HR-ASD or LR infants.

3. Emotional expression

HR infants (and HR-ASD infants) may become increasingly less positive in affect in their interactions over time. A non-significant trend towards more negativity was found at 6 months in HR infants (Cassel et al., 2007), while HR-ASD infants specifically were more negative at 14 months but not at 7 months (Wan et al., 2013).

Furthermore, parent-directed or ‘social’ smiles in HR infants did not differ from those of LR infants at 6 months (Rozga et al., 2011), but between 9 and 18 months, such smiles increased in the HR group (Harker et al., 2016). This latter finding may reflect increased dyadic interaction (i.e. gaze to parent) among the HR group rather than increased positive affect per se (see ‘Social communication’ section).

4. Vocal features

Studies found no risk group differences in vocal frequency or coordination characteristics in the first year, including interactive partner’s vocal response lag (Northrup and Iverson, 2015; Paul et al., 2011). However, HR infants produced fewer speech-like vocalisations, which did not increase between 6 and 12 months unlike the distinct growth observed among LR infants (Paul et al., 2011). This HR delay is also reflected in a slower decrease in non-speech production, lower 9-month use of canonical syllable shapes (associated with true babbling), and (particularly in HR-ASD infants) lower use of various consonant types (Table 1).

At 12 and 18 months, LR but not HR dyads showed vocal prosodic matching (Quigley et al., 2016). Furthermore, mean pitch decreased among LR group mothers from 12 to 18 months, which may reflect a move away from infant-directed (or ‘motherese’) speech, while the mothers of HR infants increased their pitch on average over the same period. However, a number of other vocal prosody characteristics measured did not differ by risk group.

5. Motor and sensory behaviours

A small study found that HR infants showed less movement and object manipulation than LR infants at 12 months, but no differences in sensory, play, or other motor behaviours, including stereotypies and aversive responses (Mulligan and White, 2012). Wan et al. (2012) reported less liveliness at 7 months in HR infants compared with LR infants, but this did not persist to 14 months and was unrelated to later ASD outcome (Wan et al., 2013).

PII by ASD outcome

Just over half of the reviewed studies (8/15) analysed PII by subsequent ASD outcome, of which five studies required participants meet full DSM-IV criteria for ASD at 36 months (assessed by clinical judgement combined with standardised measurement) for a positive ASD outcome, totalling 48 infants (Table 1). Of these studies, a number of positive findings were reported but with little overlap in the PII variables measured.

Compared with HR-noASD children, HR-ASD children were less socially reciprocal and showed fewer show/give gestures at 11 months (Campbell et al., 2015), slower growth in communicative combinations at 12 months (Parladé and Iverson, 2015), and more negative affect and less attentiveness to their parent at 14 months (Wan et al., 2013). In Winder et al. (2013), HR-ASD infants (n = 3) showed fewer communication initiations and vocalisations from 13 months. By contrast, no group differences emerged in the infants’ degree of positive affect or parent-directed vocalisations (Campbell et al., 2015; Parladé and Iverson, 2015).

Three studies in which ASD outcome was more provisional in part or all of their sample, reported that HR-ASD infants vocalised fewer of specific types of consonant that varied across the first year (Paul et al., 2011) and conveyed fewer meanings through a single gesture at 12 months (Talbott et al., 2015), but showed no 6-month differences in gaze, smiles or vocalisation to their mother within PII at 6 months (Rozga et al., 2011).

Parents of HR-ASD infants have shown no significant differences in interactive behaviour from HR-noASD infants despite the fairly large number of such variables studied (Baker et al., 2010; Campbell et al., 2015; Talbott et al., 2015; Wan et al., 2013). Talbott et al. (2015) reported that mothers of non-diagnosed HR infants gestured more frequently than mothers of LR infants (but not more frequently than mothers of HR-ASD infants). Mothers of HR-noASD infants also conveyed a higher number of meanings through each gesture.
PII in relation to non-ASD developmental outcomes

Six HR studies examined PII in relation to developmental outcomes other than ASD diagnosis (Table 1). Yirmiya et al. (2006) found no link between 5-month synchrony and 14-month cognition, language and non-verbal communication. However, others found that the number of early consonants infants used at 6 months (Paul et al., 2011) and gesture production at 12 months (Talbott et al., 2015) were positively associated with later infant language outcomes, while amount of 9-month infant speech interrupting or chiming in during maternal vocalisations predicted language delay status (Northrup and Iverson, 2015). Given the early age at which most of these PII measures were taken, it was not possible to control for baseline infant language scores. Regarding parental interaction, Baker et al. (2010) found that sensitive structuring, a component of maternal sensitivity, at 18 months was related to 2- to 3-year expressive language change in infants who were later diagnosed with ASD. Also reporting on maternal responsiveness, Leezenbaum et al. (2014) found that the proportion of verbal labelling responses that mothers provided to their 13-month-old infant’s point or show gestures was associated with later (18 month) word production in the overall sample; however, such maternal responses to HR infant gestures were uncommon. Furthermore, Talbott et al. (2015) reported that maternal gesture use with their 12-month-old infants was associated with later child language in the LR and HR-no-ASD groups only.

Discussion

At-risk studies have made strides in demarcating how PII is affected in emergent ASD, focused mainly on the first half of the child’s second year. An emerging developmental picture reveals that children with eventual autism (and the broader phenotype) and their primary caregiver interact with each other in some ways that depart from a typical trajectory in the latter months of the child’s first year. The strongest evidence was found for preverbal communication delays, including gesture use, prelinguistic vocalisations and vocal-gesture coordination, mirroring trajectories reported in the wider HR literature based on experimenter-led structured interactions (Landa et al., 2007; Ozonoff et al., 2010; Yoder et al., 2009). A second consistent finding, based on two good quality studies, is that of lowered interactive reciprocity or mutuality, which one study further found predicted later ASD symptom severity better than did social behaviours generally in HR infants. Divergence in both interactive reciprocity and infant preverbal communication are apparent in the few months after the first birthday, although delays in gesture use do not seem to affect parental interactive behaviour. Weaker evidence based on single studies report that during PII, infants with eventual ASD demonstrate less attentiveness to parent and more negative affect, and HR infants (more generally) exhibit less movement, less object manipulation, and less advanced vocal characteristics than LR infants. These findings are consistent with atypicalities found outside of PII’s at 1 year predictive of ASD outcome (e.g. Clifford et al., 2013; Ozonoff et al., 2010, 2008); though the evidence for motor delay is more mixed (see Jones et al., 2014). Taken together, these PII studies demonstrate that these infants’ early atypicalities are measurable within play interactions with caregivers, and that uniquely PII features (i.e. reciprocity, mutuality) may be affected.

Generally consistent with studies of parents of older children with ASD (e.g. Siller and Sigman, 2002; Van IJzendoorn et al., 2007), a number of studies reviewed consistently found no interactive differences in parents of infants with eventual ASD from those of infants without eventual ASD. Irrespective of ASD outcome, HR infants may tend to be have different social opportunities or inputs from LR controls, such as reflected in a more directive style and less prosodic matching. Thus, while some HR parents appear to adjust to possible infant atypicalities by decreasing social input, others may use compensatory behaviours in attempting to enrich the infant’s social environment (e.g. retaining infant-directed speech in later infancy, increasing gesture use or verbal labelling of infant gestures); such impacts on infant outcomes and later parent–child interactions require further investigation. Our secondary aim was concerned with the prediction of later social and communicative outcomes from PII in infants with emergent ASD. Language outcomes in toddlerhood were associated with various communicative delays or differences within PII in the first year. Whether such early differences shape subsequent social experiences that are important for language development, or whether they simply reflect a continuity in neurodevelopmental delay is unclear. Other single PII studies suggest that parental sensitive structuring (or scaffolding) may optimise child expressive language growth in those with eventual ASD, and that parental labelling in response to HR infant object-sharing gestures may promote word production. Thus, PII study findings seem to differentiate the parental provision of a communicative framework that may be quite highly structured (social scaffolding aimed to enhance social opportunities) from parental ‘directive’ behaviours (as defined in PII studies to include intrusive and demanding behaviours), where our review suggests that, at least in infancy, the former enhances, and the latter reduces, socio-communicative response.

Methodological limitations

Despite advances in understanding PII in HR infants, it remains unclear whether such differences by subsequent ASD outcome are the result of cascading effects on ASD severity rather than simply reflecting emergent ASD. Drawing clear conclusions is further limited by the
heterogeneity of studies, most notably in the age of infant samples and the PII variables measured. Some studies included fathers whose PII’s may tend to differ from those of mothers (e.g. Feldman, 2003). Studying PII in HR infants is resource intensive; this is reflected in the sample sizes of most studies, a third of them involving fewer than 15 HR infants, and five studies following up to 3-year ASD diagnosis. Thus, significant effects may have been difficult to detect, and no studies reported effect sizes. Sample representativeness is unclear from study descriptions and a self-selection bias is likely. A likely publication bias must be considered when evaluating these studies, as positive results are more likely to be published than negative findings.

Clinical and research directions

This first review on PII in infants at autism risk demonstrates how early emerging atypicalities and delays may alter their social experiences and that of their parents’. The findings highlight the usefulness of brief videotaped PII as a context for measuring infant behaviours and vocalisations in a more naturalistic setting than experimental paradigms and offer the advantage of observing the interactive partner’s behaviour, partly affected by the infant, and the possible consequences of any interactive alterations. As yet, however, no HR studies explicitly test bidirectional effects within PII trajectories, and only one study tested PII effects to social-communicative development in eventual ASD (Baker et al., 2010). Measuring PII longitudinally in larger samples is needed to investigate the impact that parental strategies may have, positive or otherwise, on longer term outcomes.

The findings of this review suggest that very early intervention in infancy and early toddlerhood may target PII, which may be beneficial in itself, and for optimising social and communicative outcomes. Although most early interventions are parent-mediated and therefore alter PII, two approaches have been taken, one being primarily relational (works on ‘realigning’ PII to effect socio-communicative outcomes) and the other being a coaching strategy (which ‘directs’ social enrichment – thus altering PII – to effect socio-communicative outcomes).

Taking a primarily relational strategy, Green et al. (2015, 2017) demonstrated in their parent-mediated intervention using non-directive guidance with HR infants (who were selected on familial risk) that prodromal symptoms reduced, with effects on parental aspects of interaction (directiveness reduced and synchrony increased) and infant aspects of interaction (attentiveness to parent and communication initiation increased). Our review supports the benefits of targeting these PII areas. Other recommended targets are infant gesture use, dyadic reciprocity and (with less evidence) infant vocalisation delays.

Most early interventions use a primarily coaching approach with symptomatic infants and (mostly) toddlers and have demonstrated child social engagement and communicative improvements by training parents to apply developmentally appropriate behavioural principles to daily routines and play (e.g. Bradshaw et al., 2017; Kasari et al., 2010; Rogers et al., 2014). Using this approach, the PII dynamic is altered through the parent’s use of coached enrichment strategies. This approach lies somewhat at odds with the current findings, which suggest PII as an important focus for intervention along with preliminary evidence for parental sensitive structuring to support language development in HR-ASD infants. Thus, an important empirical question is raised: Where along the continuum from sensitive structured behaviours to directive behaviours may be most beneficial for enhancing, for example, shared attention and infant gesture use, and subsequent communicative and relational outcomes in HR infants? Parent-mediated interventions can serve as a vehicle to test for such causal mechanisms.

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