Infants at Risk for Autism Spectrum Disorder: Gestures in Infants and Mothers

Doctor of Philosophy, 2013

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Abstract

Infants with an older sibling diagnosed with an autism spectrum disorder (ASD) have a twentyfold increase in risk of developing ASD. Deficits in gesture use are among the first signs of impairment in infants later diagnosed with ASD. Typically, infants develop gestures incidentally in the context of social interactions with their parents. However, infants at risk for ASD may not acquire gestures within these natural interactions. The first purpose of this research was to determine whether infants at high risk for ASD show patterns of communicative and play gestures that are delayed and/or different relative to low-risk infants. The second purpose was to compare mothers of infants at risk for ASD with mothers of infants at low risk for ASD in their use of gestures, gesture strategies, and prompts.

Seventeen 15-month-old infant-mother dyads were recruited from a longitudinal study of the emergence of autism symptoms in infants with an older sibling with ASD (high risk for ASD, n = 8; low risk for ASD, n = 9). Infant gestures were examined in three contexts: during clinical assessment, during naturalistic play with their mothers, and by parent report. Maternal gestures and gesture-related behaviours were recorded during the play interaction. Infant and maternal gesture behaviours were later coded from video.
High-risk infants showed different patterns of gesture use relative to low-risk infants. In clinic and home contexts, high-risk infants: (a) used gestures that were not directed to a communicative partner more often than low-risk infants, and (b) showed specific deficits in the use of deictic and joint attention gestures. In addition, high-risk infants: (a) demonstrated fewer symbolic play acts at home, and (b) had a smaller inventory of communicative and play gestures by parent report. Mothers of high-risk infants used more play gestures, but were otherwise no different in their gesture behaviours from mothers of low-risk infants. This research demonstrated that, at 15 months of age infants at risk for ASD showed delays and differences in gesture use despite receiving typical gestural input from their mothers. The patterns of these deficits may be important in early identification and could inform intervention practices.
# Table of Contents

Abstract

List of Tables

List of Figures

Introduction

Method

Results

Discussion

References

Appendix A. Orientation to Study and Instructions for Mothers

Appendix B. Caregiver Perception Rating Form (Home Visit)

Appendix C. Caregiver Perception Rating Form (Clinic Visit)

Appendix D. Telephone Script for Contacting Mothers Scoring Seventeen or Higher on the BDI-II

Appendix E. Gesture Coding Manual: Infants

Appendix F. Gesture Coding Manual: Mothers
List of Tables

Table 1.  Types of Gestures .................................................................6
Table 2.  Communicative Functions of Gestures ..................................7
Table 3.  Characteristics of High- and Low-Risk Infants .....................39
Table 4.  Characteristics of Mothers of High- and Low-Risk Infants ......40
Table 5.  Ethnic Backgrounds of Mothers with High- and Low-Risk Infants .................................................................42
Table 6.  Descriptions and Examples of Infant Codes ..........................53
Table 7.  Descriptions and Examples of Codes for Mothers ..................55
Table 8.  Percentage Agreement for Infant Behaviours and Infant Symbolic Play Acts Coded (Clinic and Home Contexts), Maternal Gestures and Related Behaviours, and Maternal Symbolic Play Acts Coded ..................................................58
Table 9.  Reliability Coefficients and Percentage Agreement for Infant Gestures (Clinic and Home Contexts) .................................................................59
Table 10. Percentage Agreement and Reliability Coefficients for Mothers’ Gestures, Prompts, and Gesture Strategies to Augment Spoken Language ..........59
Table 11. Means and Standard Deviations for Directed and Non-Directed Gestures in Clinic and Home Contexts by Group .................................................63
Table 12. Mean Proportion (as percentage) of Non-directed Gestures for Individual Cases Averaged Across Clinic and Home Contexts .........................................70
Table 13. Mean Rates and Standard Deviations for Types of Gestures in Clinic and Home Contexts by Group .................................................................72
Table 14. Means and Standard Deviations for Functions of Gestures in Clinic and Home Contexts by Group .................................................................80
Table 15. Means and Standard Deviations for Infant Symbolic Play Acts in Clinic and Home Contexts by Group .................................................................86
Table 16. Means and Standard Deviations for Overall Rate of Maternal Gestures and Types of Gestures by Group .................................................................90
Table 17. Means and Standard Deviations for Communicative Functions of Maternal Gestures by Group .................................................................93
Table 18. *Means Rates and Standard Deviations for Maternal Gesture Strategy by Group* ................................................................. 96

Table 19. *Summary of Within-Group Profiles of Directedness, Types, and Functions of Gestures for High- and Low-Risk Infants in Clinic and Home Contexts* ........... 111
List of Figures

Figure 1. Recruitment and Procedures

Figure 2. Profile Plot for Mean Rates of Directed and Non-Directed Infant Gestures in a Clinic Context

Figure 3. Profile Plot for Mean Rates of Directed and Non-Directed Infant Gestures in a Home Context

Figure 4. Profile Plot for Mean Rates of Types of Infant Gestures in a Clinic Context

Figure 5. Profile Plot for Mean Rates of Types of Infant Gestures in a Home Context

Figure 6. Profile Plot for Mean Rates of Communicative Functions of Infant Gestures in a Clinic Context

Figure 7. Profile Plot for Mean Rates of Communicative Functions of Infant Gestures in a Home Context

Figure 8. Mean Rates and Standard Deviations of Infant Symbolic Play Acts in a Clinic Context

Figure 9. Mean Rates and Standard Deviations of Infant Symbolic Play Acts in a Home Context

Figure 10. Mean Number and Standard Deviations of Parent-Reported Early and Late Gestures

Figure 11. Profile Plot for Mean Rates of Types of Maternal Gestures

Figure 12. Profile Plot for Mean Rates of Communicative Functions of Maternal Gestures

Figure 13. Mean Rates and Standard Deviations of Maternal Symbolic Play Acts

Figure 14. Profile Plot for Mean Rates Showing Maternal Gesture Strategies Used to Augment Spoken Language

Figure 15. Mean Rates and Standard Deviations of Maternal Prompts to Encourage Infant Gesturing
Autism, which forms part of a spectrum known as the Autism Spectrum Disorders (ASD), is a complex neurodevelopmental disorder with a unique constellation of symptoms characterized by qualitative impairments of social interaction, verbal and non-verbal communication, and by the presence of repetitive, inflexible behaviours and interests (Bertrand et al., 2001; Chakrabarti & Fombonne, 2001). Recent epidemiological estimates indicate the prevalence of ASD is 1 in 88 (Autism and Developmental Monitoring Network Surveillance Year 2008 Principal Investigators and Center for Disease Control, 2012). Autism spectrum disorders are widely considered to have substantial genetic heritability (Lauritsen, Pedersen, & Mortensen, 2005; Szatmari et al., 2000; also see Weiss, 2009 for review). Therefore, infants who have an older sibling with ASD are at increased genetic risk of developing ASD. Previous recurrence in siblings has been estimated at about 10% (Constantino, Zhang, Frazier, Abbacchi, & Law, 2010; Sumi Taniai, Miyachi, & Tanemura, 2006) or at least a twentyfold increase (Bailey, Phillips, & Rutter, 1996; Lauritsen et al., 2005; Ritvo et al., 1989) relative to population prevalence. More recently, the largest prospective study of recurrence in high-risk siblings, Ozonoff et al. (2011) estimated a recurrence rate of 18.4% in infant siblings of children with ASD.

Prospective studies comparing the development of infants with an older sibling with ASD (high-risk infants) to those with low genetic risk for ASD have identified a number of early diagnostic indicators. By 24 months of age, high-risk infants who go on to have ASD show a unique constellation of behaviours including social and communication deficits (Brian et al., 2008; Landa, Holman, & Garrett-Mayer, 2007; Ozonoff et al., 2010; Toth, Dawson, Meltzoff, Greenson, & Fein, 2007, Sullivan et al., 2007; Yoder, Stone, Walden, & Malesa, 2009; Zwaigenbaum et al., 2005). Specific impairments occur in the acquisition of communicative gestures (Iverson & Wozniak, 2007; Landa et al., 2007; Luyster, Lopez, & Lord, 2007; Mitchell et al., 2006; Zwaigenbaum et al., 2005) delayed receptive (Ozonoff et al., 2010; Zwaigenbaum, et al., 2005) and expressive language (Iverson & Wozniak, 2007; Ozonoff et al., 2010; Zwaigenbaum, et al., 2005), atypical patterns of visual orienting and attention (Landa et al., 2007; Nadig et al., 2007; Ozonoff et al., 2010;
Zwaigenbaum et al., 2005), and a distinctive pattern of temperament (Zwaigenbaum et al., 2005). Moreover, high-risk infant siblings who do not go on to have ASD also demonstrate developmental differences that are qualitatively similar but less severe than those seen in infants who are later diagnosed. Developmental differences include social and communication deficits (Constantino et al., 2010; Toth et al., 2007) with specific impairments in the acquisition of communicative gestures (Mitchell et al., 2006; Toth et al., 2007), and delayed receptive and expressive language (Constantino et al., 2010; Gamliel, Yirima, & Sigman, 2007; Toth et al., 2007). While there is robust evidence in the literature indicating a constellation of deficits in infants who go on to have ASD, the lack of onset of first words remains the primary reason that parents first seek professional advice (Coonrod & Stone, 2004; De Giacomo & Fombonne, 1998). Because communicative gestures emerge developmentally earlier than first words, identifying deficits and patterns of early gesture use in high-risk infant siblings can inform diagnostic assessment practices in the earliest identification of infants most at risk for developing ASD.

Impairments in gesture use are among the earliest signs of non-verbal communication impairment in high-risk infants and differentiate infants who are later diagnosed with ASD from infants with typical development (Adrien et al., 1993; Maestro et al., 2001; Maestro et al., 2005; Mitchell et al., 2006; Osterling & Dawson, 1994; Osterling, Dawson, & Munson, 2002; Zwaigenbaum et al., 2005). Impairments in communicative gestures include those used to direct others’ behaviour (e.g., giving items to an adult to get help); to participate in social interactions including play (e.g., peek-a-boo); and to coordinate attention between people and objects (e.g., pointing). In infants who go on to have ASD, these impairments in gesture use persist through preschool (Charman, Drew, Baird, & Baird, 2003; Luyster, Lopez, et al., 2007; Mundy, Sigman & Kasari, 1990; Wetherby et al., 2004) and school-age periods (Loveland & Landry, 1986; Stone & Caro-Martinez, 1990; Stone, Ousley, Yoder, Hogan, & Hepburn, 1997).

Gestures have an important role in early communication (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979), language development (Mundy & Gomes, 1998; Watt, Wetherby, & Shumway, 2006; Thal & Tobias, 1992), and play (Bates et
Early gesture use is predictive of language outcomes in both typical (Carpenter, Mastergeorge, & Tomasello, 1998; Rowe, Özçalişkan, & Goldin-Meadow, 2008; Thal & Tobias, 1992; Watt et al., 2006) and atypical development (Luyster, Qui, Lopez & Lord, 2007; Mundy et al., 1990; Stone & Yoder, 2001). Thus, impairments in early gesture use may negatively impact these other important areas of development. Intervention targeting gestures in infants showing early signs of ASD may increase success in early social interactions and help minimize deficits in other developmental domains that early impairments in gesture use forecast. In order to create developmentally appropriate, effective, impairment-specific intervention for infants at risk for ASD, it is necessary to understand the nature of gestural development during the prelinguistic period of development. Thus, research examining gesture differences may contribute to the development of early interventions for high-risk infants.

Typically developing infants use gestures to communicate long before the onset of spoken words. Infants acquire gestures incidentally, during natural social interactions with their parents (Namy, Acredolo, & Goodwyn, 2000; Namy & Nolan, 2004; Namy, Vallas, & Knight-Schwartz, 2008). Thus, parents have an important role in influencing their infants’ acquisition of prelinguistic skills. Studies investigating parent-child interaction have shown that parents who adopt responsive interaction strategies can positively impact the communication development of children with ASD (Aldred, Green, & Adams, 2004; McConachie, Randle, Hammad, & Le Couter, 2005; Siller & Sigman, 2002). In particular, increasing parents’ use of gestures has been shown to increase gesture use in typically developing infants (Goodwyn, Acredolo, 1998; Goodwyn, Acredolo, & Brown, 2000). Whereas typically developing infants acquire gestures in the context of social interactions with their parents, infants at risk for ASD do not appear to acquire gestures within these natural interactions with their parents.

Examining gesture use in parents of infants at risk for ASD to determine whether differences exist in the gestural input these infants receive may be important for understanding why infants at risk show early gestural deficits. In
addition, research that contributes to our understanding of how parents of infants at risk for ASD use gestures as well as how they encourage infant gesture development may be useful in optimizing parents as agents of change in order to improve outcomes for these infants. The objective of this dissertation was thus twofold. Its primary objective was to examine gesture use in 15-month-old infants at risk for ASD. The secondary objective was to examine maternal gesture use and investigate the role of mothers in encouraging infant gesture use.

The review that follows will provide an overview of gesture use in infants with typical development and those with ASD, followed by a synopsis of gesture-related, parent–child communication literature. The review is followed by a discussion of the gaps in the status of the current literature with respect to gesture use in infants at risk for ASD and their mothers.

Defining Gestures

A gesture is defined as an action produced using the body, hands, fingers, or mouth for the purpose of communication (Cartmill, Beilock, & Goldin-Meadow, 2012; Iverson & Thal, 1998; Wetherby & Prizant, 2002). This definition implies that the action is directed toward a person, and specifically indicates communicative intent. To illustrate, Wetherby and Prizant (2002) define a gestural communicative act as one that: (a) is a gesture, typically expressed using hands and fingers, although it may also include facial movements (e.g., lip smacking) or body movements (e.g., bouncing of the body for a horsie game); (b) is directed toward another person (e.g., produced while looking at someone); and (c) serves a communicative function (e.g., to request an object). Although gesture definitions in the literature vary to some extent, there is agreement that a gesture includes the physical action of producing it, its directedness to a person, and the communicative purpose for producing it.

The current literature uses two taxonomies to classify gestures: type and communicative function. There are three types of gestures: deictic, conventional, and representational, and three communicative functions: behaviour regulation, social interaction, and joint attention (Bruner, 1981). Thus, a single gesture can be
described by its type and function. Operational definitions of the three types and the three functions of gestures are provided in Tables 1 and 2, respectively.

What should be included in and excluded from the category of representational gestures has been the source of much debate. Some researchers, (Iverson & Thal, 1998; Shumway & Wetherby, 2009) include conventional gestures in the broader category of representational gestures, arguing that representational and conventional gestures both “establish reference” and “indicate semantic content.” Others have argued that these categories are distinct. It has been argued that conventional gestures have a specific, often culturally defined, form. By contrast, representational gestures encapsulate features of an object (e.g., shape, function) that are often generated from the speaker’s perspective and therefore do not have a specific (i.e., incorrect) form (Cartmill et al., 2012). For example, “round and round” could be indicated by using an index finger to draw circles in the air or by rolling the head around in circles. Here, representational gestures are considered unique from conventional gestures and are distinctly defined in Table 1.
Table 1

Types of Gestures

<table>
<thead>
<tr>
<th>Gesture Type</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deictic</td>
<td>Single out objects or events by calling attention to or indicating the object or event in the conversational space (e.g., point, reach, show, give).</td>
</tr>
<tr>
<td>Conventional</td>
<td>Establish reference but do not represent an object; represent particular semantic content; have consistent form with meaning that can be culturally defined (e.g., move finger side to side for no-no) or less culturally defined (e.g., nod the head for yes); include emotive (e.g., whole body bounce) and contact gestures (e.g., push hand away).</td>
</tr>
<tr>
<td>Representational</td>
<td>Establish reference to objects, persons, or events; represent particular semantic content of the attributes of (e.g., arms out for plane) actions performed by (e.g., scratch armpits for monkey), or with the referent (e.g., cupped hand to mouth for drinking).</td>
</tr>
</tbody>
</table>

Adapted from Cartmill, Beilock, and Goldin-Meadow, 2012; Crais, Douglas, and Campbell, 2004; Iverson and Thal, 1998.

An additional source of debate in the field of gesture research relates to whether recognitory gestures should be considered as gestures. Recognitory gestures are defined as play actions performed with a toy object in hand. Because these gestures are produced with an object (e.g., drinking from a toy cup) some researchers believe they and are not in and of themselves communicative and should therefore not be defined as gestures (Acredolo & Goodwin, 1988; Iverson, Capirici, & Caselli, 1994). On the other hand, several lines of evidence support the argument that these gestures, like representational gestures, are symbolic and should be considered gestures (Bates, Bretherton, Shore, & McNew, 1983; Caselli, 1990; Escalona, 1973; McCune-Nicholich, 1981; McCune, 1995; Werner & Kaplan, 1963). Actions performed with objects in hand (i.e., recognitory gestures) serve as a foundation for the production of actions with objects out of hand (i.e.,
representational gestures) that are then used communicatively. Despite this debate, there is agreement that the ability to perform these actions with (and later without) objects reflects knowledge of functions or attributes of objects, which represents a symbolic understanding that contributes to language development. Thus, the following description of the development of gestures in typical infants includes studies that have examined play actions with objects using a variety of descriptors (i.e., pretend play, symbolic play actions, recognitory gestures). For the purpose of the review, these variables will collectively be understood and referred to as symbolic play acts.

Table 2

*Communicative Functions of Gestures*

<table>
<thead>
<tr>
<th>Communicative Function</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behaviour Regulation</td>
<td>Gestures used to regulate the behaviour of another person. Include: request for objects (e.g., point to ask for juice); request for actions (e.g., give object to ask for help); and protest (e.g., push hand away for <em>all done</em>, shake head <em>no</em>)</td>
</tr>
<tr>
<td>Social Interaction</td>
<td>Gestures used to draw the attention of another person to oneself. Include: request for social routine (e.g., cover eyes for <em>peek-a-boo</em>); show off (e.g., dance); greet or call (e.g., wave); acknowledge a person’s previous statement or action (e.g., wave in response to another’s wave); request permission or comfort (e.g., arms up for <em>pick me up</em>).</td>
</tr>
<tr>
<td>Joint Attention</td>
<td>Gestures used to direct another’s attention to an object or event. Include: comment (e.g., show an object of interest); request information (e.g., arms out for <em>where?</em>); request clarification (e.g., point for <em>this one</em>).</td>
</tr>
</tbody>
</table>

Adapted from Bruner, 1981.
Gestures in Typical Development

The development of gestures is a robust phenomenon with types, communicative functions, and inventories of infant gestures emerging similarly across cultures (Blake, Vitale, Osborne, & Olshansky, 2005) and socio-economic status (Fenson et al., 1994; although see Rowe & Goldin-Meadow, 2009). Gestures develop in the context of natural interactions with caregivers (Bruner, 1975b; Vygotsky, 1978). Infants begin to use gestures in their interactions with others at about six months of age, well before the onset of spoken words. Gestures are considered non-linguistic behaviours. However, similar to language, these non-linguistic behaviours are used intentionally by infants to communicate and are the first evidence of symbolic representation forming a bridge to language symbols. Adamson, Bakeman, and Smith (1990) offer this description: “An infant’s first gestures and words are a developmental link between communication by ‘action’ and communication by ‘symbol’ (p. 31).”

Two important aspects of gesture acquisition in typical infant development will be presented. First, the developmental sequence of gesture type and function acquisition will be reviewed for infants up to 18 months of age. Second, findings from studies examining the relationship between gestures and the acquisition of language will be presented.

Developmental sequence. There is great deal of variability in individual maturational schedules with regard to the development of gestures (Fenson et al., 1994). That is, while some typically developing infants may begin pointing by 9 months of age, others may not produce this gesture until 10 or 11 months of age. This variability is reflected in somewhat disparate findings in the experimental literature on the emergence of gesture types and functions in infancy. To further complicate the developmental picture, variability in the methodologies of the experimental studies of gesture development (i.e., context, communicative partner, measurement) has resulted in different age estimates for the emergence of gestures. Moreover, several studies examined only one type of gesture (e.g., Bates et al., 1979; Carpenter et al., 1998; Perucchini & Camaioni, 1993) or provided a detailed description of emergence using non-experimental diary studies with very few
infants (e.g., Blake & Dolgoy, 1993), or provide only single case studies (e.g., Acredolo & Goodwyn, 1988; Caselli, 1990; Masur, 1990). Thus, the developmental sequence of gestures that follows is drawn from the findings from two seminal studies (Carpenter, Mastergeorge, & Coggins, 1983; Crais, Douglas, & Campbell, 2004) that longitudinally examined the emergence of gestures and provided a detailed description of their types and functions. Descriptions of procedures for the collection of infant data are described below.

Crais, Douglas, and Campbell (2004) reported the sequence in which gesture types and functions emerge in 12 infants from 6 to 24 months of age. Spontaneous parent–infant interactions and researcher-infant interactions were videotaped monthly. Parents further reported on gestures observed of these interactions. Parents were then asked to elicit gestures reported but not seen during the spontaneous interaction session. Infant gestures were coded for type and function from videotape. Carpenter et al. (1983) conducted a detailed study of the emergence of communicative functions in six typically developing infants from 8 to 15 months of age. Mother-infant dyads were videotaped monthly in a clinical setting during both unstructured and elicited play interactions with a set of selected toys. Infants were coded for intentionally communicative behaviours, including gestures.

It is important to note that describing the order in which types and functions of gestures emerge is difficult as these are not distinct elements; rather, each gesture can be described both by the type of gesture that it is and by the communicative function that it serves. For example, although pointing emerges at a relatively predictable time in development, pointing for the communicative function of requesting (i.e., behaviour regulation) emerges earlier than pointing for the function of commenting (i.e., joint attention).

**Gesture development by type.** Infants begin to use gestures intentionally at about six months of age and acquire a substantial number of gestures between six and nine months of age. These gestures appear first in dyadic (i.e., person–person) and later in triadic (person-object-person; Bakeman & Adamson, 1984) interactions. The earliest gestures are produced first without vocalization (Crais et al., 2004) and then are almost consistently accompanied by vocalizations, and later, words (Crais
et al., 2004; Masur, 1990). The first gestures to appear are primitive conventional gestures and are evident at approximately 6–7 months of age (Crais et al., 2004). These early conventional gestures are less sophisticated than those that appear later in development and include emotive gestures and contact gestures. Emotive gestures tend to be made with the whole body for the purpose of social interaction and include anticipatory body postures such as “whole body lean away” and participatory behaviours or performatives (Bates et al., 1979) such as “bounce body” for “horsie game” or “dancing.” Contact gestures are made when the infant comes in physical contact with another person and include “push away with arm” to protest (i.e., behaviour regulation). The first deictic gesture to appear is a whole-hand reach to request an action or object (behaviour regulation), which emerges at approximately 7–8 months of age. At approximately 8–9 months of age, more sophisticated conventional gestures emerge such as “arms up” to be picked up, “reaching for comfort,” “waving,” and “clapping” in social games.

Between 9 and 12 months of age, infants acquire all deictic gestures. Over this period the more primitive “whole hand reach” is used less often in favour of “open and close hand,” which becomes consistently coordinated with vocalization at 9–10 months of age. Infants learn to “give” and “show” objects to invite a partner into joint attention interactions (9–10 months of age) and begin to “point” to request objects (i.e., behaviour regulation) and comment (i.e., joint attention) at about 10–11 months of age. Deictic gestures emerge first as contact gestures (i.e., objects in hand) and later as distal gestures (i.e., pointing). Conventional gestures that emerge at this stage include the earlier appearing “clapping” and “waving” (but in new contexts such as spontaneous greeting or to share enjoyment), dancing, and showing the function of objects (i.e., recognitory gestures).

Between 12 and 15 months of age, infants learn to generalize deictic gestures to other communication functions. At approximately 14 months of age, infants use a “point” to request information and begin to combine gestures with word approximations. The conventional gestures “blow kiss,” “nod,” and “shake head” for social interaction and joint attention emerge at approximately 15 months of age.
During the 15– to 18–month age period, the repertoire of conventional gestures continues to develop and includes “fingers to lips” for “shhh,” for social interaction and for joint attention functions. “Shrug shoulders” is used for “I don’t know” and for joint attention. Age 15 months marks the onset of representational gestures. Infants learn to “smack lips” as if eating or sharing enjoyment in pretend play and use “hand on side of face” as if sleeping. Representational gestures appear first in the context of social games such as “spider hands” for “Itsy Bitsy Spider” (i.e., contextualized) and later are used outside this context to request the social game, comment, or request (i.e., decontextualized). Representational gestures that represent an action or attribute of an object follow early object use (i.e., recognitory gestures).

**Gesture development by function.** With respect to the order in which the communicative functions of gestures emerge, variability in both individual infants and methodology (e.g., context, measurement, communication partner) introduce variability to estimates of emergence sequence. The order of emergence of communicative functions is also more intertwined than that of gesture type (see Table 1). However, there is general agreement that infants first use gestures for behaviour regulation and social interaction (i.e., by nine months of age) prior to using gestures for joint attention, which emerge after nine months of age (Carpenter et al., 1983; Crais et al., 2004). This is congruent with the progression from dyadic to triadic communication, since gestures for social interaction are wholly dyadic and those for behaviour regulation include dyadic interactions. By definition, joint attention gestures occur only in triadic interactions (Carpenter et al., 1998). Although Bates et al., (1979) did not examine gestures for social interaction, they reported that gestures for behaviour regulation (imperatives) emerged consistently earlier than those for joint attention (declaratives).

**The association between gestures and language in typical development.** The acquisition of gestures and language are tightly coupled developmental processes. Gestures become disassociated from language during the transition to spoken words (Butcher & Goldin-Meadow, 2000; Fenson et al., 1994; Volterra & Erting, 1990) but remain predictive of later language abilities (Bates, Camaioni, &
It has been theorized that, in infancy, gestures serve as a transitional modality to spoken language. Volterra and Erting (1990) proposed that gestures, specifically recognitory gestures, function as a bridge from infants’ command of receptive referents to their active involvement in labeling referents in social interactions. Empirical support for the bridge hypothesis in typical development comes from work that suggests infants use gestures as a bridge between language comprehension and production (Bates, Thal, Fenson, Whitesell, & Oakes, 1989; Charman et al., 2003; Fenson et al., 1994; Luyster, Lopez, et al., 2007). In other words, gestures are used as labels for referents until spoken words are established. Fenson et al. (1994) examined the relationship between word comprehension, word production, and gesture production. They found that if the third variable was held constant, word comprehension was correlated with word production and gesture production, but that word production was not correlated with gesture production. In keeping with bridge theory, word and gesture production were not correlated because infants demonstrate an expressive communication mode preference relative to their developmental abilities. That is, infants may prefer to use a gestural label until they are able to produce a verbal label.

It is important to note that although the association between gesture acquisition and language acquisition is robust in typical development, the mechanism by which infants use gestures to acquire language may be indirectly mediated by parents. Increased infant communication yields additional opportunities for parents to provide language models (Calandrella & Wilcox, 2000; Yoder & Warren, 2002). Thus, parental language input likely functions as a mediating mechanism that contributes to language outcomes in infants.

**Gestures in ASD**

**Gestures in preschool and school-aged children with ASD.** Examinations of gesture use in preschool and school-aged children with ASD have revealed persistently delayed (Charman et al., 2003; Luyster, Lopez, et al., 2007; Mundy, Sigman, Ungerer, & Sherman, 1986; Wetherby, Prizant, & Hutchinson, 1998;
Wetherby & Prutting, 1984; Wetherby, Woods, Allen, Cleary, Dickinson, and Lord, 2004) and deviant (Baron-Cohen, 1989; Charman et al., 2003; Mundy et al., 1986; Stone et al., 1997; Wetherby, Prizant, & Hutchinson, 1998) patterns of gesture development.

Evidence to support delays in the acquisition of gestures include a smaller inventory of communicative and symbolic gestures for the child’s age (Charman et al., 2003; Luyster, Lopez, et al., 2007; Mundy et al., 1986; Wetherby & Prutting, 1984; Wetherby et al., 2004), decreased frequency of gesture use (Mundy, Sigman, Ungerer, & Sherman, 1987; Sigman, Mundy, Sherman, Ungerer, 1986), and more frequent use of primitive contact gestures beyond the age at which these gestures are used in typical development (Shumway & Wetherby, 2009).

Delayed gesture use has been well documented in the extant literature (Charman et al., 2003; Luyster, Lopez, et al., 2007; Wetherby et al., 1998; Wetherby et al., 2004). Children with ASD have a smaller inventory of gestures with fewer social communicative and symbolic play gestures relative to normative samples (Charman et al., 2003; Luyster, Lopez, et al., 2007; Wetherby et al., 2004; Wetherby et al., 1998) and compared to experimental groups of children with developmental language delays (Wetherby et al., 1998), developmental delay (DD), and typical development (TD; Luyster, Lopez, et al., 2007). In addition to smaller inventories of gestures, children with ASD use more primitive contact gestures (e.g., pushing a hand away, pulling a person by the hand) and less sophisticated conventional gestures than children with DD or TD (Loveland & Landry, 1986; Stone & Caro-Martinez, 1990; Stone, Ousley, Yoder, Hogan, & Hepburn, 1997).

Evidence for deviant gestural developmental patterns in ASD includes an atypical profile of gesture types and functions. Children with ASD have been differentiated from children with DD and TD on the basis of having fewer deictic gestures (Sigman et al., 1986; Mundy et al., 1986; Stone et al., 1997; Mundy et al., 1990) and a lower frequency of gestures use for the function of joint attention (Sigman & Ruskin, 1999; Stone & Caro-Martinez, 1990; Stone et al., 1997) as compared to children with TD and DD. Further, symbolic play actions appear to be delayed while functional play remains relatively intact and mirrors the typical
developmental order of acquisition (Mundy et al., 1986; Sigman and Ruskin, 1999). In addition, children with ASD have shown stronger symbolic play acts than communicative gestures, suggesting stronger cognitive–linguistic abilities than social communicative abilities (Charman et al., 2003).

**Associations between gestures and language in ASD.** Delayed gesture acquisition in children with ASD suggests that, with additional maturation and experience, they may acquire gestures on a developmental course that is similar to (but may occur later than) that seen in typical development. Thus, the association between gesture and language outcomes would be expected to be similar to that seen in typically developing infants. On the other hand, a deviant pattern suggests that gesture acquisition follows an altered trajectory, which suggests that the association between gestures and language in this population may be different than that seen in children with typical development and children with other developmental delays.

Examinations of the gesture–language association in preschool and school-aged children with ASD have demonstrated that gestures and symbolic play actions are correlated with language abilities (Charman et al., 2004; Mundy et al., 1987; Sigman & Ruskin, 1999). Moreover, inventory and frequency of gesture use are predictive of language outcomes. Inventory of gestures and symbolic play acts is concurrently (Luyster, Kadlec, Carter, & Tager-Flusberg, 2008) and longitudinally predictive of a child’s language abilities (Charman et al., 2004; Drew, Baird, Taylor, Milne & Charman, 2007; Luyster, Qui, et al., 2007; Mundy et al., 1990; Sigman & Ruskin, 1999). In addition, frequency of non-verbal communication (including gestures) and symbolic play acts is longitudinally predictive of language abilities in children with ASD (Charman et al., 2004; Drew et al., 2007; Mundy et al., 1990; Mundy et al., 1987; Sigman & Ruskin, 1999; Stone & Yoder, 2001).

The role of gestures in the transition to spoken words in young children with ASD appears to be similar to that found in typical development, lending support for the theoretical notion that gestures are a bridge to spoken language. Two studies examined parent-reported social communication and symbolic play gestures in preschoolers with ASD (Charman et al., 2003; Luyster, Lopez, et al., 2007). Both
studies demonstrated that word comprehension was correlated with gesture and word production but that word production was not correlated with gestures. This pattern of correlations is consistent with that found in typical infants (Fenson et al., 1994), indicating that young children with ASD may also use gestures as a bridge to spoken language.

In summary, despite evidence of delays in the acquisition of gestures and a deviant pattern of gesture use in children with ASD, the association between early gesture use and later language abilities is similar to that seen in children with TD. Moreover, there is specific support for the theory that in ASD, as in typical development, gestures are closely tied to the acquisition and use of language and play a foundational role in the transition to spoken words. Gesture use in infancy may underlie the acquisition of language for children with ASD and impairment may alter their developmental course.

**Emergence of gestures in infants with ASD.** Determining when gesture development begins to differ from a typical course of acquisition is important for two reasons. First, the detection of impaired gesture use in infancy can contribute to the early identification of ASD. Second, difficulty acquiring gestures in infancy can be expected to negatively impact the development of communication, language, and play. Thus, providing intervention at the first sign of delay may minimize deficits in social communication and the acquisition of language and play seen in older children with ASD. However, examining the emergence of gestures in infants with ASD is difficult because children are often not diagnosed until well after the age of five years (Shattuck et al., 2009). Several methodological designs that address this challenge have been used to examine the emergence of gestures in infancy in children with ASD.

Information regarding the acquisition of gestures in infants and toddlers with ASD has been gained using two research methodologies: *retrospective* studies of infants who were later diagnosed with ASD and *prospective* studies of infants at risk for ASD. Studies with retrospective designs include parent report of their infants’ early development provided after diagnosis and analyses of pre-diagnosis home videos. Prospective studies examine emerging signs of autism in a population
of infants who are at risk for ASD. These include infants at increased genetic risk (i.e., high-risk infant sibling studies) and community samples of infants later diagnosed with ASD (i.e., community-referred samples). High-risk infant sibling studies monitor the development of infants who have an older sibling with ASD because these infants have at least a twentyfold increase in the risk of ASD relative to population estimates of prevalence (Bailey et al., 1996; Ozonoff et al., 2011; Sumi et al., 2006; Szatmari et al., 2000). Community-referred samples involve screenings of infants and subsequent secondary assessments for those identified at risk for social communication delays.

The body of literature examining gesture use in infancy and toddlerhood encompasses studies with varying degrees of detail with respect to the aspects of gestures studied. Several studies included gestures under the broad category of “communication.” Others examined only a specific gesture (e.g., pointing), or a specific type (e.g., deictic), or function (e.g., social interaction) of a gesture. A limited number of studies included a detailed examination of gestures with joint consideration of all gesture types and functions. The review below includes first studies of gestures in general, followed by those that examine gestures more specifically by considering either types or functions, and finally studies that consider both types and functions.

When considering early gesture development in ASD, it is important to determine whether impairment in the acquisition of gestures is due to cognitive impairment or is symptomatic of ASD specifically. Children with ASD show delays in the onset of developmental milestones that may be similar to those of children with other types of developmental delays. Prevalence estimates indicate that 43% (male) to 54% (female) of children with ASD also have cognitive impairment (Shattuck et al., 2009). Therefore, specific comparisons between infants with ASD and those with other DDs are highlighted below.

**Retrospective studies of gesture development in infants with ASD.**

Retrospective studies offer a number of methodological advantages in the examination of early gesture use in ASD. First, these studies are ecologically valid. Retrospective parent reports of infants later diagnosed with ASD describe social
communication behaviours that have occurred spontaneously in a number of environments with familiar adults, thereby providing a summative description that is likely representative of infants’ skills. Similarly, home videos of infants later diagnosed with ASD provide useful documentation of the social communication behaviours that occurred spontaneously in natural settings with familiar adults and activities. Because they are recorded prior to diagnoses and often prior to the onset of parental concern, the videos minimize *therapeutic scaffolding* of infant communication by parents.

Retrospective studies examining gesture use in infants using home video analysis have reported an overall decreased frequency and smaller inventory of gestures. By 24 months of age, infants later diagnosed with ASD have fewer communicative gestures compared to typically developing infants (Adrien et al., 1993; Maestro et al., 2001; Osterling et al., 2002) and infants with DD (Osterling et al., 2002). Moreover, by 12 months of age, decreased frequency of gesture use (Maestro et al., 2001), symbolic play actions (Clifford, Young, & Williamson, 2007) and smaller inventories of gestures (Colgan et al., 2006) differentiate infants at risk from infants with typical development. In their retrospective study of first birthday videos, Osterling et al. (2002) demonstrated that infants with ASD, both with and without co-occurring DD, gestured less than infants with TD and those with DD by 12 months of age.

A number of studies have examined gestures in more detail by considering types and/or functions of gestures. The development of deictic gestures, particularly pointing and showing, has received much attention in the literature, likely because of the known deficits in joint engagement in older children with ASD. Decreased pointing (Maestro et al., 2001; Mars, Mauk, & Dowrick, 1998) and showing (Clifford et al., 2007; Mars et al., 1998) differentiated 12- to 24-month-old infants with ASD from typical infants. Deficits in pointing and showing that are evident by the end of the second year of life begin to deviate from a typical trajectory at 12 months of age. In their study of first birthday videos, Osterling and Dawson, (1994) reported that less pointing and showing reliably distinguished infants with ASD (with and without co-occurring DD) from infants with TD. These impairments did not appear to vary as
a function of cognitive impairment. Although Adrien et al. (1993) and Maestro et al., (2001) did not find group differences in overall frequency of gesture use in their comparisons of infants with ASD with typically developing infants, these studies included infants with a broad range of ages, which may have masked group differences. The Adrien et al. (1993) study examined gestures in two groups of infants under the age of 12 months; however, the ASD group included infants as young as two weeks of age (age ranges for typically developing infants were not reported). This study included infants who were developmentally younger than the age at which gestures are expected to emerge, which may have masked group differences resulting in null findings with respect to gesture frequency. Similarly, Maestro et al. (2001) compared the gestures of 6- to 12-month-old infants (15 typically developing and 15 infants later diagnosed with ASD). The inclusion of this wide range of ages, in combination with the significant variability of gesture acquisition in typical maturational schedules, may have masked group differences in 6–12 month group comparisons.

Specific deficits in the use of deictic gestures also differentiate infants with ASD from those with other DDs. Clifford and Dissanayake (2008) examined deictic gestures in 12- to 24-month-old infants using home video analysis and parent report. Parents reported that their infants with ASD had increased difficulty following another’s point; demonstrated less pointing, giving, and showing for interest; and less pointing and giving for requests. Video analysis results were consistent with parent reports showing decreased rates and poorer quality of declarative (i.e., pointing, showing, giving, pushing objects toward a person to comment) and imperative gestures (i.e., pointing, giving, and reaching to request) compared to infants with TD and infants with DD (Clifford & Dissanayake, 2008).

Colgan et al. (2006) examined gestures for the specific function of social interaction in a retrospective video analysis of gesture use in 9- to 12-month-old infants later diagnosed with ASD. Compared to typical infants, those with ASD had a smaller inventory of gestures for social interaction, although the frequency of their use of these gestures in dyadic interactions with their mothers was not different from that of typical infants. That is, infants with ASD were able to gesture for the
purpose of social interaction at a similar rate to typical infants but they used a minimal number of gestures to do so.

Taken together, retrospective studies have contributed two important findings to our knowledge of how gesture use in infants at risk for ASD compares to that of infants with typical development and those with other developmental delays. First, infants at risk for ASD use communicative gestures and symbolic play actions less frequently and have smaller inventories of gestures compared to infants with typical development. Moreover, relative to infants with DD, infants at risk show a decreased inventory and frequency of communicative gestures. These differences point to a delayed trajectory of development, evidence of which appears between the first and second year of life. Second, infants at risk for ASD show particular deficits in the use of deictic gestures relative to infants with TD and DD, which also emerge between the first and second year of life. This specific deficit in deictic gestures points to these infants having a unique profile of gesture types, suggesting a deviant trajectory of development, at least for this gesture type.

Despite these contributions, our understanding of the development of gestures in infants with ASD is incomplete due to several limitations and gaps in the extant literature. As previously mentioned, several studies were limited by the age ranges studied. In addition, there are no retrospective studies specifically examining conventional and representational gestures in infants at risk for ASD. Thus, it is not possible to draw a definitive conclusion about whether infants at risk for ASD have a deviant trajectory specific to deictic gestures. Furthermore, retrospective studies have not examined the communicative functions of gestures in infants at risk for ASD. Finally, there are additional gaps in the literature stemming from the methodological limitations of retrospective designs.

First, retrospective parent reports are subject to recall biases. Second, home videos may not be representative of an infants’ typical behaviour. That is, parents may be more likely to videotape motivating activities that yield mainly positive behaviour or represent infants’ best skills. Third, variability in the contexts within which data were gathered makes comparisons of results across studies difficult. Although many studies using retrospective home video analysis made efforts to
match for social context (e.g., family vacation or first birthday), these contexts did not necessarily include the same activities. Moreover, the activities that were used to sample gestures may not have adequately captured a range of gestures. The specific activities within which gestures are sampled considerably influence the types and, particularly, the functions of gestures that infants use. For example, “hands over eyes” for peek-a-boo would likely only occur in the context of the peek-a-boo game; a snack activity may provide more opportunities for requesting gestures (i.e., behaviour regulation function); and pointing is more likely to occur during an activity that provides an opportunity to request an object or comment on a novel toy. In order to compare the types and functions of gestures in groups of infants, it is necessary that activities be uniform across infants to ensure equal opportunity for the occurrence of each type and function of gesture. However, retrospective designs preclude controlling the activities within which gestures were sampled.

Differing methods of coding gestures have also limited generalizability of findings across studies. Although some uniformity was achieved by using standardized coding within studies, behavioural coding across the reviewed studies varied considerably. Coding methods to evaluate how frequently gestures were used included: percentage of occurrence (Clifford et al., 2007), duration of use (Osterling et al., 2002), qualitative judgments of frequency (i.e., never, continuously; Adrien, et al., 1993), and interval coding (Maestro et al., 2001; Mars et al., 1998; Osterling & Dawson, 1994). Interval coding entails coding whether a gesture was present or absent in a given interval. Intervals ranged from one to three minutes across studies. This coding method assumes that a well-established behaviour is likely to occur within the interval. However, other factors may influence the likelihood of occurrence, such as whether an opportunity was provided for spontaneous production versus whether an opportunity was presented; the infants’ level of motivation; or whether a gesture is emerging or established. For infants with ASD, gestures may have been learned within and thus be associated with a known activity, resulting in an overestimate of the infants’ abilities. Conversely, interval coding ignores other examples of the gesture used within the interval, thus
underestimating infants’ abilities. The longer the interval, the more discrepant the data become.

**Prospective studies of gesture development in infants with ASD.** Studies with prospective designs, including parent report and direct observation, offer numerous advantages over retrospective designs. First, these designs allow the examination of communicative behaviours at specific age points, thus limiting parent recall biases. Second, prospective designs have the advantage of systematically sampling and measuring specific target behaviours as they emerge (i.e., observation of spontaneous behaviours and elicitation of behaviours not observed) and thereby include a broad range of communication behaviours.

Most prospective infant studies have examined non-verbal communication and have included gestural communication under the broader category of communicative gestural acts. Results have indicated that by 24 months, infants with ASD have a decreased frequency of non-verbal communication compared to infants with TD (Landa et al., 2007; Shumway & Wetherby, 2009; Wetherby, Watt, Morgan, & Shumway, 2007; Wetherby et al., 2004) and infants with DD (Shumway & Wetherby, 2009; Wetherby et al., 2007; Wetherby et al., 2004). Only one prospective study has specifically examined the frequency of gestural communication in infants with ASD younger than 24 months of age. In a multi-group study of infants aged 18 to 24 months, Shumway and Wetherby (2009) examined the rate of gestural communicative acts in infants with ASD (n = 50), DD (n = 25) and typically developing infants (n = 50). The ASD group had a significantly lower overall rate of gesture use compared to both of the other groups, with authors reporting large effect sizes.

Consistent with findings for preschool children, infants with ASD also exhibit smaller inventories of gestures. Prospective studies have examined infant gesture inventories using parent report, specifically the MacArthur Bates Communicative Development Inventory (MCDI; Fenson et al., 1993). Compared to low-risk infants, infants later diagnosed with ASD had fewer communicative and symbolic play gestures than low-risk control infants at 12 months (Mitchell et al., 2006; Zwaigenbaum et al., 2005) and 18 months of age (Mitchell et al., 2006).
Consistent with parent reports, prospective studies of high-risk infant siblings have also demonstrated smaller inventories of gestures in infants later diagnosed with ASD using direct observation in a clinical setting. Bryson, Zwaigenbaum, et al. (2007) gave a detailed description of the early development of nine infants with and without cognitive delays who were later diagnosed with ASD. By 18 months of age, all nine infants were described as having few or no gestures. Similarly, Brian et al. (2008) showed that, relative to low-risk controls, infants later diagnosed with ASD used significantly fewer gestures by 18 months of age. Landa et al. (2007) examined high-risk infants longitudinally at aged 14 months and again at 24 months. Relative to non-ASD infants, high-risk infants had smaller inventories of gestures and symbolic play acts at both time points. Prospective studies of community-referred high-risk infants under 24 months of age also reported smaller inventories of symbolic play acts in this group compared to typical infants but reported no group differences with respect to infants with DD (Wetherby et al., 2007; Wetherby et al., 2004).

With respect to types of gestures, Iverson and Wozniak, (2007) compared the onset age of pointing and showing in high-risk and low-risk infants. Onset of pointing and showing was determined using parent report on the MCDI (Fenson et al., 1993), completed at monthly intervals from 5 to 14 months of age. A significantly higher proportion of infants in the high-risk group attained showing (but not pointing) later than the median age of onset for infants in the low-risk group (9.05 months and 8.94 months respectively).

Parallel with findings in preschool children with ASD, studies specifically examining deictic gestures have demonstrated that 18- to 24-month-old infants at risk for ASD had a lower frequency of deictic gestures (Shumway & Wetherby, 2009), particularly pointing and showing (Wetherby et al., 2004) compared to infants with typical development. Moreover, compared to infants with developmental delay, those at risk for ASD had a lower frequency of deictic gestures (Shumway & Wetherby, 2009), particularly showing (Wetherby et al., 2004). Shumway and Wetherby (2009) specifically examined profiles of gesture types used within groups. The group with ASD had a lower proportion of representational
gestures and a higher proportion of contact gestures, whereas the group with TD had the reverse profile. In addition, within-group comparisons showed that the group with ASD had significantly more contact gestures than deictic gestures, whereas the group with TD had more deictic than contact gestures.

Only three prospective studies have examined the communicative functions of gestures in infants at risk for ASD (Landa et al., 2007; Shumway & Wetherby, 2009; Wetherby et al., 2007). These studies included gestures within the broader category of communicative acts. Landa et al. (2007) longitudinally compared high- and low-risk infants aged 14 and 24 months and found that high-risk infants had fewer communicative acts for behaviour regulation and joint attention at both time points. They did not report findings with respect to the communicative acts for social interaction. Similarly, high-risk infants aged 18 to 24 months have been shown to use fewer communicative acts for behaviour regulation, social interaction, and joint attention compared to infants with TD, and fewer communicative acts for joint attention compared to infants with DD (Shumway & Wetherby, 2009; Wetherby et al., 2007).

By examining inventory, frequency, and profiles of gesture types, the Shumway and Wetherby (2009) study provides the most comprehensive, prospective evaluation of prelinguistic communication and is thus particularly relevant to the study of gesture use in infants at risk for ASD. Unfortunately, unlike gesture types, profiles of gesture functions were not examined separately in the study. Instead, the authors examined profiles of the functions of communicative acts and included gestures in this category. The fact that this study collapsed analyses of infants in the age range of 18 to 24 months is also problematic because particular gestures may differentiate diagnostic groups only at specific ages (e.g., Lord, 1995). In addition, the rate of gestural communication predictably decreases in the second year of life in typical development (Locke, Young, Service, & Chandler, 1990). Gesture use steadily increases in the prelinguistic period of development but decreases in frequency as infants transition to using spoken words, beginning at approximately 16 months of age (Butcher, & Goldin-Meadow, 2000; Goldin-Meadow & Morford, 1990; Iverson et al., 1994).
The prospective literature has generated three important findings. First, these studies have revealed through parent report that infants at risk for ASD have smaller inventories of communicative gestures and symbolic play acts than typically developing infants, evidence for which emerges at 12 months of age and persists through to 24 months of age (Iverson & Wozniak, 2007; Mitchell et al., 2006; Zwaigenbaum et al., 2005). Direct observation in clinical contexts has also shown a decreased inventory of gestures and symbolic play acts compared to typically developing infants (Landa et al., 2007; Wetherby et al., 2004; Wetherby et al., 2007) and a decreased inventory of gestures (but not symbolic play acts) compared to infants with DD (Wetherby et al., 2004; Wetherby et al., 2007) in infants 18 to 24 months of age. Second, prospective studies have demonstrated decreased frequency of gesture use in infants at risk for ASD compared to typically developing infants (Landa et al., 2007; Shumway & Wetherby, 2009; Wetherby et al., 2007) and infants with DD (Shumway & Wetherby, 2009; Wetherby et al., 2007). Third, prospective studies have indicated a unique profile of gesture types characterized by particular deficits in deictic gesture use (Shumway & Wetherby, 2009) that is evident at 18 months of age.

Notwithstanding the contributions of prospective studies, several gaps in our knowledge of gesture use in infants at risk for ASD remain. Data with respect to inventories of infants’ gesture use in ASD were collected primarily using two methods: parent report or direct observation. Parent-reported data show good reliability with data from clinical assessments (e.g., Glascoe, 1997) but yield somewhat different information with respect to gestures than direct observation methods. Parent-reported gesture use can be thought to represent an inventory of gestures used in a range of natural settings but provides little information regarding the communicative quality of the gestures (e.g., coordinated with eye gaze, vocalization) or whether gestures are emerging or established. Prospective designs allow more controlled sampling of specific gestures. Sampling gestures through direct observation provides an opportunity to examine the quality of the gestures. In addition, this method allows the use of elicitation procedures. However, direct observation of gesture use in infants with ASD has been conducted only in
structured clinical settings. Sampling gestures in both home and clinical settings may contribute important information with respect to infant gesture use. No prospective studies included measures of gesture inventories using both parent-reported data and direct observation in the same sample of infants.

With respect to frequency of gestural communication, it is important to note that, although gestures were included in measures of communication in many prospective studies, only one study demonstrated decreased frequency of gesture use specifically (Shumway & Wetherby, 2009). Several prospective studies examined profiles of communicative functions in high-risk infants. Unfortunately, gestures were again included in the measure of communicative functions, but were not examined specifically in most studies to date.

**Role of Parents in Gesture Development**

Parents play an important role in their infants’ acquisition of developmental skills. Theoretical support for the notion that caregivers have a critical role in the acquisition of developmental skills comes from the field of developmental psychology. Vygotsky (1978) and Bruner (1981) believed that learning takes place within social contexts, with more competent communicative partners (parents) providing scaffolding for less competent communicative partners (infants), allowing a graduated acquisition of skills. Bruner has described the nature of this scaffolding: “a child’s participation in habitualized interactions within familiar social contexts forms the elemental basis for the development of first communication and then language abilities” (Bruner, 1975b).

Empirically, evidence also shows that parents naturally provide interaction supports, acting as mediators to scaffold infants’ communication (and other behaviours) in order to enable the infant to acquire skills beyond their independent abilities (see Snow, 1995 for review). Furthermore, empirical evidence has shown that parents can learn novel methods to scaffold infant development and that these methods influence language and communication outcomes in infants with typical (Goodwyn, & Acredolo, 1998; Goodwyn et al., 2000; Namy & Nolan, 2004) and atypical development (Aldred et al., 2004; McConachie et al., 2005; Siller & Sigman, 2002).
Mothers of infants with typical development. Mothers naturally modify a number of their child-directed behaviours when interacting with their young children. Perhaps the best-known modifications mothers make with respect to their child-directed communication and language is what is referred to as motherese (see Snow, 1995 for review). Mothers also adjust their play behaviours to the developmental level of their child (Bakeman & Adamson, 1984; Stevenson et al., 1988); they will, for example, modify their actions with objects when interacting with children in ways they do not when with adults (referred to as motionese; Brand et al., 2002).

With respect to gesture use, mothers have been shown to modify their child-directed gestures relative to gestures used with adults in much the same way. Mothers use fewer gestures with infants compared to what they use with other adults (Shatz, 1982). Moreover, maternal gestures toward children are less conceptually complex (i.e., less representational) and tend to be paired one-to-one with verbal utterances (Iverson et al., 1999; Shatz, 1982). In terms of child-directed gesture types, mothers primarily use deictic gestures with fewer of the conventional and representational types (Iverson et al., 1999; O’Neill et al., 2005; Shatz, 1982).

Mothers use gestures to supplement their spoken language in interactions with their infants. These gesture strategies serve to (a) emphasize or convey meaning that is semantically equivalent to the verbal utterance, (b) disambiguate the verbal utterance, or (c) add information to the verbal utterance. Iverson et al. (1999) studied maternal gesture use with infants aged 16 and 20 months. At both time periods, mothers used gestures primarily to emphasize their verbal utterances, producing fewer gestures to disambiguate verbal utterances and even fewer to add information. O’Neill et al. (2005) demonstrated analogous findings in a structured counting task and an unstructured play task in 20-month-old infants and their mothers.

Several studies have highlighted an association between mothers’ gestures and infants’ gestures (Acredolo, & Goodwyn, 1988; Iverson et al., 1999; Namy et al., 2000) and mothers’ gestures and infant vocabulary production (Namy & Nolan, 2004). Infants spontaneously imitate the gestures that their mothers produce.
(Acredolo, & Goodwyn, 1988; Namy & Nolan, 2004; Namy et al., 2000). In a longitudinal study of typically developing infants, Acredolo and Goodwyn (1988) demonstrated, through analysis of weekly parent diaries, that infants between the ages of 11 and 20 months spontaneously imitated novel symbolic gestures modeled by their mothers during joint activity routines. Moreover, infants later used these novel gestures communicatively outside these routines to refer to both objects and pictures of objects in a clinic setting.

The frequency of maternal gesture use has been shown to be concurrently predictive of infant gesture use (Acredolo, & Goodwyn, 1988; Iverson et al., 1999; Namy et al., 2000). Namy et al., (2000) examined the relationship between gesture production in 15-month-old infants with typical development and the gestural input of their mothers (n = 80). Authors reported strong correlations between the number of maternal gestures and the number of infant gestures in both experimental (r = .63) and control groups (r = .79).

Because parents gesture and speak simultaneously, maternal gestures are inextricably linked to maternal language (Iverson et al., 1999; O’Neill et al. 2005). Correlational studies provide only indirect evidence of the association between maternal gesture use and infant gesture use and language acquisition. Thus, it is not possible to parse out the constituent influences of maternal gesture input from language input. Although a direct link between maternal gesture use and infant gesture use is not supported in the literature, it is likely, as some researchers have argued, that maternal gestural input serves to bootstrap infant gesture acquisition (Namy et al., 2000; Namy & Nolan, 2004).

**Mothers of infants with atypical development.** Mothers of infants with atypical development could be expected to adjust their communication in ways that mothers of infants with typical development do not. It is possible that, because infants at risk for ASD do not communicate in the same way as typically developing infants, mothers, in turn, may alter their infant-directed communication in response to impaired infant communication (Bell, 1968; Bell & Harper, 1977).

Relatively little is known about mothers’ communication with infants in atypical development. In the preschool period, mothers of children with DD appear
to have somewhat different interaction styles with their children compared to mothers of children without delays. Mothers of children with intellectual disabilities have been shown to initiate interaction more frequently (Eheart, 1982) and use a more directive, intrusive style of interaction (Cielinski et al., 1995; Marfo, 1992; Roach et al., 1998). Mothers of preschool children with ASD have also been shown to be more directive in their interactions with their children than mothers of children with DD (Lemanek, Stone, Fishel, 1993) and TD (Kasari, Sigman, Mundy, & Yirmiya, 1988; Lemanek et al., 1993; Watson, 1998). Mothers of infants at risk for ASD have been shown to use a more directive style even with infants as young as 6–10 months of age (Wan et al., 2012).

The directive interaction style adopted by parents of children with ASD may be reflective of the directive style of behavioural intervention used with children with autism. However, in examining parent–child interactions, there are more similarities than differences in parents and caregivers of children with ASD relative to those without. Baker, Messinger, Lyons, and Grantz (2010) examined maternal sensitivity in mothers of 18-month-old infants at risk for ASD and found no differences compared to mothers of low-risk infants. Compared to mothers of infants with TD, mothers of infants who went on to have ASD showed no differences in the level of child-directed language (Venuti, de Falco, Esposito, Zaninelli, & Bornstein, 2012) and no differences in caregiver–child synchrony compared to mothers of preschool children with typical development or children with DD (Siller & Sigman, 2002). In addition, mothers of children with ASD have been shown to initiate interactions with their infants with the same frequency as mothers of children without ASD, although they tended to use more physical contact in their initiations (Doussard-Roosevelt, Joe, Bazhenova, & Porges, 2003).

Only three studies have specifically examined maternal gesture use in children with atypical development. Iverson, Longobardi, Spampinato, and Caselli (2006) compared aspects of maternal gestural communication in mothers of preschool children with Down syndrome (DS) with those of mothers of typical children. Mothers in both groups used primarily deictic gestures. Mothers of children with DS used proportionately more deictic gestures, the most common of
which was showing. In contrast, mothers of typical infants more commonly used pointing. In addition, both groups of mothers used gestures primarily to emphasize their verbal utterances, followed by gestures to disambiguate their verbal utterances, and least often to add semantic content. Grimminger, Rohlfing, and Stenneken, (2010) compared the gesture use of mothers of typically developing toddlers with that of mothers with toddlers who were late to talk. Mothers were asked to instruct their infants to place two objects in a specific spatial orientation. Both groups of mothers primarily used deictic gestures. Mothers of toddlers who were late to talk gestured more frequently and held their gestures longer suggesting that these mothers accommodated for language difficulties by providing gestural scaffolding. Colgan et al. (2006) examined the prompts employed by mothers of 9-to 12-month-old infants later diagnosed with ASD to promote gesturing. Although two groups (ASD and TD) were included in the sample, only qualitative data were reported with respect to maternal prompts. All mothers used mainly verbal prompts (e.g., mother says “Wave bye-bye”) to encourage infant gestures. They produced fewer instances of modeling a gesture or physically (i.e., hand over hand) prompting infant gestures.

In the studies described above, mothers of infants with atypical development have been shown to modify some of their communicative behaviours because of developmental differences in their children. In addition to factors intrinsic to the child, factors intrinsic to mothers can also be expected to affect communication with their atypical infants. Maternal psychopathology, specifically depression, has been shown to impact infant–mother interactions as well as aspects of infant outcomes (Murray & Cooper, 2003; Murray, Fiori-Cowley, Hooper, & Cooper, 1996b). Mothers of infants at increased genetic risk for ASD may be more likely to have symptoms of depression or be part of the broader autism phenotype (Constantino & Todd, 2000; Constantino & Todd, 2005; Piven, Palmer, Jacobi, Childress, & Arndt, 1997). The term broader autism phenotype (BAP) has been used to describe a profile of social and communication deficits, repetitive interests and behaviours characteristic of autism but with a milder presentation. ASD is a genetically heritable disorder (Lauritsen et al., 2005), therefore it is possible that mothers of children with ASD
may have some of the same social communication deficits (particularly their use of gestures) seen in ASD. These factors are important to consider when examining communication in mothers of infants at risk for ASD.

In summary, the extant literature comparing several aspects of the parent–child interactions of parents of children with ASD and parents of typically developing children has revealed more similarities than differences between these two groups. There are no known studies examining gesture use in parents of children with ASD and only one qualitative study examining how parents of high-risk infants encourage infant gesturing. However, it is evident that infants at risk for ASD are not learning gestures in the same way. Understanding this difference is important in order to determine whether mothers of infants at risk for ASD provide similar gestural input to their infants.

**Rationale for Present Study**

**Gestures in infants at risk for ASD.** Deficits in the use of gestures are one of the earliest signs of a delay in infants at risk for ASD. Gestures are pivotal to the development of communication, language, and play, all of which are areas of difficulty for children with ASD. Understanding the nature of the deficits in gesture use exhibited in this population of infants may contribute to the development of interventions focused on developing gestures. In turn, improvements in gesture use may influence prelinguistic communicative competence, symbolic play, and the acquisition of language in infants at risk for ASD. Thus, the first purpose of this study was to compare the use of gestures in infants at risk for ASD with that of typically developing infants. This study extends our current knowledge of gesture use in infants at risk for ASD by addressing the gaps and methodological limitations in the extant literature.

This study uses a prospective design in order to sample a targeted range of types and functions of gestures and to determine whether infants at risk have a unique profile of gesture types and functions. Infant gestures were examined at a uniform age in order to minimize variability in types of gestures expected at different ages. Further, gestures were examined at the developmentally salient time
point of 15 months of age, prior to the decrease in frequency of gesture use that coincides with the onset of spoken words at 18 months of age.

Infant gestures were sampled in three contexts (i.e., clinic, home, and parent report) in order to obtain the most accurate representation of infant gesture use. Direct observation methods provide better a representation of gesture use with respect to frequency and quality of gesture use than parent-reported methods. Because outcomes for infants with ASD are influenced by both their inventory of gestures (Drew et al., 2007; Luyster, Lopez, et al., 2007) and frequency of gestural communication (Drew et al., 2007), sampling gestures in both contexts was seen as important. A parent-reported measure was included to provide an estimate of infants’ inventory of gestures. The clinic context was included to provide additional opportunities to elicit infant gestures. The home context was included to examine spontaneous gesture use in a naturalistic setting with a familiar adult. The lack of consistency in the activities used to sample gestures in retrospective studies to date was addressed by selecting a standardized clinical measure of gestural communication that included a set of specific activities sampling a range of gesture types and functions. A similar set of activities was selected for the home context.

Infant gesture use in this study was examined using rate (e.g., per minute). Rate of gesture use more accurately reflects whether a gesture is emergent or established, which addresses the limitations of interpreting frequency of gesture use using interval coding.

In addition to gesture types and functions, this study investigated whether infants at risk for ASD directed their gestures toward a person. As described earlier, three elements, taken together, conventionally define a gesture: (a) an action produced with the hands, arms, fingers, body, or face, that is (b) directed to a person; and (c) serves a communicative function. However, it was hypothesized that gesture use in infants at risk for ASD might not contain all components; for example, it is possible that infants produce gestures (i.e., actions with arms, hands, etc.) but may not direct them to a communication partner. All studies to date have excluded gestures that were not directed to a person from the data analysis, and thus may possibly have missed an important feature of gestures in infants at risk.
Gestures in mothers of infants at risk for ASD. Investigating the gestural input of mothers of infants at risk for ASD as well as how mothers facilitate the emergence of gestures may provide a window of opportunity for optimizing the emergence of this skill. This premise is based on social-interactionist theories (e.g., Bruner, 1981; Vygotsky, 1978) and empirical evidence (Aldred et al., 2004; McConachie et al., 2005; Siller & Sigman, 2002) that lend support to the tenet that mothers (and fathers) have a significant influence on their infants’ acquisition of developmental skills. Parents who optimally adapt their communication style to promote gesture development may provide valuable insight into how infants at risk for ASD develop gestures, social communication, play, and ultimately language skills. Thus, the second purpose of this study was to compare mothers of infants at risk for ASD with mothers of infants at low risk for ASD with respect to their use of gestures, how their gestures related to the language they use, and the use of maternal strategies to encourage infant gestures.

Gestural communication in mothers of infants at risk for ASD has not been examined in the current literature. With the exception of limited, quantitative data with respect to maternal prompts to encourage infant gesture use, other behaviours related to gesture use in mothers of infants at risk for ASD have also not been investigated. Thus, the evaluation of maternal gestures and related behaviours is a novel contribution to the extant literature. Maternal behaviours were examined in the home context during naturalistic play activities with their infants. All maternal behaviours were examined using rate (e.g., behaviours per minute).

Research Questions and Hypotheses

Research questions: infants.

1. Compared to low-risk infants, do infants at risk for ASD have the same profile of gesture directedness (i.e., use of directed and non-directed gestures) in structured assessment activities with a clinician and in naturalistic interactions with their mother?
2. Compared to low-risk infants, do infants at risk for ASD have the same profile of gesture types (deictic, conventional, and representational) in structured
assessment activities with a clinician and in naturalistic interactions with their mother?

3. Compared to low-risk infants, do infants at risk for ASD have the same profile of communicative functions (behaviour regulation, social interaction, and joint attention) of gestures in structured assessment activities with a clinician and in naturalistic interactions with their mother?

4. Compared to low-risk infants, do infants at risk for ASD have the same inventory of communicative and symbolic gestures by parent report?

5. Compared to low-risk developing infants, do infants at risk for ASD have the same rate of symbolic play acts in a structured clinical context and in a naturalistic home context with their mothers?

**Hypotheses: infants.**

1. Infants at risk for ASD are expected to have different profiles of gesture directedness than low-risk infants. Infants later diagnosed with ASD have been shown to use gestures less often than infants with typical development in both retrospective and prospective studies (Adrien et al., 1993; Maestro et al. 2001; Osterling et al., 2002). Based on studies of preschool children with ASD who demonstrate difficulty coordinating language with other non-verbal modes of communication (Phillips, Gomez, Baron-Cohen, Laa, & Riviere, 1995; Shumway & Wetherby, 2009; Stone et al., 1997; Wetherby et al., 1998), high-risk infants are expected to have a profile of lower directed gestures and higher non-directed gestures in both structured activities with a clinician and naturalistic activities with their mothers.

2. High-risk infants are expected to have a different profile of gesture types than low-risk infants. Previous findings demonstrating specific deficits in the use of deictic gestures (showing and pointing) distinguished infants who went on to have ASD from typically developing infants (Clifford et al., 2007; Maestro et al., 2001; Mars et al., 1996; Osterling & Dawson, 1994). Thus, it is expected that infants at risk for ASD will produce fewer deictic than conventional or representational gestures.
3. High-risk infants are expected to have different profiles of gesture functions than low-risk infants. Based on previous findings showing specific deficits in communicating for the purpose of joint attention (Mundy et al., 1990; Shumway & Wetherby, 2009; Wetherby et al., 2007; Wetherby and Prutting, 1984) infants at risk for ASD are expected to produce more gestures for the function of behaviour regulation than for joint attention and social interaction, whereas typically developing infants will not show this pattern.

4. It is expected that infants at risk for developing ASD will have a smaller inventory of gestures by parent report relative to low-risk infants. Previous findings (Colgan et al., 2006; Mitchell et al., 2006) have demonstrated that infants who went on to have ASD had a smaller inventory of gestures than typically developing infants.

5. Based on findings showing lower rates of symbolic play acts among infants with ASD relative to infants with typical development (Wetherby et al., 2007) high-risk infants are expected to use symbolic play acts at a lower rate than low-risk infants.

**Research questions: mothers.**

1. Compared to mothers of low-risk infants, do mothers of infants at risk for ASD have the same rate of overall gesture use in naturalistic interactions with their infants?

2. Compared to mothers of low-risk infants, do mothers of infants at risk for ASD have the same profile of *types* of gestures used (e.g. deictic, conventional, representational)?

3. Compared to mothers of low-risk infants, do mothers of infants at risk for ASD have the same profile of communicative *functions* of gesturing in naturalistic interactions?

4. Compared to mothers of low-risk infants, do mothers of infants at risk for ASD have the same profile of maternal gesture *strategies* (e.g., to emphasize meaning, disambiguate, or add information to verbal communication) used to augment spoken language?
5. Compared to mothers of typically developing children, do mothers of infants at risk for ASD have the same profile of prompts (modeling, verbal and physical prompting) to encourage their infants to gesture?

**Hypotheses: mothers.** To date there are no known studies of maternal gesture use in mothers of infants at risk for ASD. Thus, hypotheses for mothers of infants at risk for ASD were based on the increased likelihood that these mothers would be part of the broader autism phenotype (BAP) and/or have clinical depression. Given that at least one child in the family had a diagnosis of ASD before the present study began, mothers in this sample were at increased risk of showing social communication difficulties consistent with those seen in the BAP (Constantino & Todd, 2000; 2005). The presence of such social communication difficulties was predicted to influence: (a) the profile of types and functions of maternal gesture use, (b) the profile of gesture strategies used to supplement spoken language, and (c) the rate of symbolic play.

Having a child with ASD may increase symptoms of maternal depression, which has been shown to negatively impact mother–child interactions (Murray & Cooper, 2003; Murray et al., 1996b). Based on the increased possibility of mothers of infants in the high-risk group having clinical depression, these mothers could be expected to have a decreased frequency of gestures, symbolic play acts, and prompts to encourage infant gestures relative to mothers of low-risk infants. It is expected that mothers of infants at risk for ASD will use gestures at a lower rate than mothers of low-risk infants.

In addition, mothers of infants at risk for ASD could be expected to show a decreased rate of gestural communication and play based on Bell’s Bidirectional Theory, which states that not only do parents influence their children but children also affect their parents’ behaviour (Bell, 1968; Bell & Harper, 1977). Therefore, if infants at risk for ASD use fewer gestures, it is possible that mothers may have lower rates of gestures, symbolic play, and prompts to encourage their infants to gesture.

1. Mothers of infants at risk for ASD are expected to have a different profile of gesture types relative to mothers of low-risk infants.
2. Mothers of infants at risk for ASD are expected to have a different profile of gesture functions relative to mothers of low-risk infants.

3. It is expected that mothers of infants at risk for ASD will have a different profile of gesture strategies to augment their spoken language.

4. It is expected that mothers of infants at risk for ASD will have a different profile of prompts used to encourage their infants to gesture.

5. Mothers of infants at risk for ASD are expected to use symbolic play gestures at a lower rate than mothers of low-risk infants.

Method

Design

The current study was embedded within an ongoing longitudinal, prospective, early identification study of infant siblings of children with ASD (Zwaigenbaum et al., 2005). The first purpose of the longitudinal study was to examine the emergence of autism symptoms in infants with at least one older sibling with ASD (i.e., infants who are at increased genetic risk of developing ASD). The second purpose of the longitudinal study was to compare infants who are at high risk of developing ASD to a group of low-risk infants with both an older sibling and a family history without ASD. The current study included a subset of participants recruited from the longitudinal study. It utilized a comparative design with two groups of infant–mother dyads: (a) infants at risk for ASD, and (b) infants who were at low risk for ASD and not showing concerning symptoms with respect to communication. Final ethics approval for this study was obtained from the Research Ethics Board at the Hospital for Sick Children (Sick Kids) on August 26th, 2008. Ethics approval for this study was also obtained from the University of Toronto, Office of Research Ethics on October 21st, 2008.

Recruitment

All infant-mother dyads were recruited from the two groups of infants in the longitudinal study: infants at risk for ASD and a control group of infants with low risk for developing ASD. Infants at risk for ASD were recruited into the longitudinal study from parent referrals through autism diagnostic centres in Ontario (McMaster Children’s Hospital, Hamilton, Ontario; The Hospital for Sick Children, Toronto,
Ontario) in which diagnosticians had previous clinical contact with the infants’ older sibling with ASD. The infants with low risk for developing ASD were recruited into the longitudinal study via information booths at annual spring and fall “Baby Time” shows, community parent–child library programs, and through word-of-mouth contact with research assistants and professionals involved in the longitudinal study. All infants and their mothers resided in Ontario and were from a large metropolitan area and its surrounding urban communities (see Figure 1).

**Inclusion and Exclusion Criteria**

Inclusion criteria for both groups of infants were established by the larger longitudinal study. Eligibility criteria for the group of infants at risk for ASD had: (a) at least one older sibling with ASD, (b) no known specific neurological or genetic condition associated with developmental delay or disorder, (c) term gestation, (d) birth weight greater than 2500 grams, and (e) English as the primary language of the home (i.e., spoken at least 80% of the time). Eligibility criteria for the group of infants in the low-risk control group had: (a) at least one older sibling without ASD; (b) no first- or second-degree relatives with ASD; (c) no known specific neurological or genetic condition associated with developmental delay or disorder, (d) term gestation, (e) birth weight greater than 2500 grams, and (f) English as the primary language of the home (i.e., spoken at least 80% of the time). A total of 74 infants who were enrolled in the longitudinal study turned 12 months old between July 2009 and February 2011 (54 infants at high risk for ASD, 20 infants at low risk).

Additional inclusion criteria were established for participation in the current study. Infants at risk for ASD had: (a) mothers who were willing to participate when their infants were aged 15 months, (b) no known hearing loss, and (c) an additional level of risk for ASD indicated by an elevated number of behavioural markers (i.e., six or more) on the *Autism Observation Scale for Infants* (AOSI; Bryson, Zwaigenbaum, McDermott, Rombough, and Brian, 2008) at 12 months of age. The AOSI is a standardized instrument that evaluates the presence of autism symptoms in infants aged 6–18 months. Items are scored as 0, 1, 2, or 3 with 0 indicating typical behaviour and scores other than 0 indicating increasing deviation from typical behaviour. Items scored other than 0 are considered “markers.” Additional
inclusion criteria for infants who were at low risk for developing ASD included: (a) mothers who were willing to participate when their infants reached 15 months of age, (b) infants with no known hearing loss, and (c) infants who passed a standardized screening of early communication development as measured by the Communication and Symbolic Behavior Scales – Developmental Profile – Infant Toddler Checklist (CSBS-DP-ITC; Wetherby & Prizant, 2002).

Of the 54 infants at risk for ASD, 46 infants and their mothers were excluded from the current study for the following reasons: 39 infants did not meet inclusion criteria (i.e., had fewer than six markers on their 12-month AOSI), one infant met inclusion criteria but was receiving treatment focused on gesture development, one infant met inclusion criteria but was not invited to participate in this study because the family was under significant psychosocial stress at the time, one infant met inclusion criteria but could not be contacted, one infant met inclusion criteria but the family declined to participate because they lived out of town, one family withdrew from the longitudinal study because they moved away, and two families were excluded because English was not the primary language of the home as initially reported. Thus, a total of eight infants at risk for ASD met inclusion criteria and participated in this study.

Of the 20 low-risk control infants, 11 infants were excluded from the current study for the following reasons: four did not pass the communication screening (i.e., demonstrated concerns in at least one composite domain on the CSBD-DP:ITC; Wetherby & Prizant, 2002), three families withdrew from the longitudinal study prior to their infants’ 15-month visit citing the demands of the study (i.e., a visit to the clinic every three months), one family declined to participate in the current study, one family was removed from the longitudinal study because the older sibling was a half-sibling, one family was unable to attend the 15-month visit, and one family participated in all aspects of the study but video data were subsequently erased in error. Thus, a total of nine infants at low risk for ASD met inclusion criteria and participated in this study.

**Participants**
**Infants.** A total of 17 infants and their mothers were the participants in this study: eight infants at high risk for developing ASD (hereafter *high-risk infants*) and nine infants with low risk for developing ASD (hereafter *low-risk infants*). Table 3 outlines the characteristics of the infants. Infants in both groups were, on average, 15 months old and there were no significant differences between the two groups in terms of age, $t(15) = .60, p = .560$. Gender distribution for the groups was comparable: the high-risk infant group included seven males and one female; the low-risk infant group included eight males and one female. Data from the Mullen Scales of Early Learning (MSEL; Mullen, 1995), a measure of infant development, were collected by the longitudinal study at each infant’s 12-month visit. High-risk infants scored significantly lower on the MSEL, $t(15) = 3.94, p = .000, d = 1.91$ and, as expected, also had significantly higher total scores on the AOSI, $z = -3.49, p = .000, r = .85$.

Table 3

*Characteristics of High- and Low-Risk Infants*

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>High-Risk Infants (n = 8)</th>
<th>Low-Risk Infants (n = 9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mos)</td>
<td>M (SD)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15.54 (.21)</td>
<td>15.44 (.39)</td>
</tr>
<tr>
<td>Min–Max</td>
<td>15.23–15.93</td>
<td>15.03–16.33</td>
</tr>
<tr>
<td>Gender</td>
<td>87.5% males</td>
<td>88.9% males</td>
</tr>
<tr>
<td>MSEL</td>
<td>M (SD)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>90.13 (22.39)</td>
<td>123.00 (7.89)</td>
</tr>
<tr>
<td>Min–Max</td>
<td>50–124</td>
<td>108–132</td>
</tr>
<tr>
<td>AOSI</td>
<td>M (SD)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12.13 (3.52)</td>
<td>2.33 (1.58)</td>
</tr>
<tr>
<td>Min–Max</td>
<td>8–18</td>
<td>1–6</td>
</tr>
</tbody>
</table>

*Note.* MSEL = *Mullen Scales of Early Learning* (Early Learning Composite Standard Score; $M = 100, SD = 15$); AOSI = *Autism Observation Scale for Infants* (Total Score at 12-month visit; maximum possible score = 38)

1 The composite score for one high-risk infant was prorated because the child completed only three of the four subscales required to compute an Early Learning
Composite. The mean of the $T$ scores from the three completed subsets was included as the score for the missing subscale.

**Mothers.** Table 4 outlines the characteristics of the 17 mothers who participated in the study. The mothers of the high-risk infants were significantly older than the mothers of the low-risk infants, $t(15) = 3.43, p = .004, d = 1.67$, which is consistent with data showing increased risk for ASD in infants with older mothers (Shelton, Tancredi, & Hertz-Picciotto, 2010). The two groups did not differ in levels of education $\chi^2(3, N = 17) = 4.36, p = .225$, which ranged from having some grade school or high school to completion of a graduate degree.

The majority of mothers spoke English as the only language in the home. In the high-risk group, one family reported speaking a language other than English in the home less than 20% of the time. In comparison, in the low-risk group, two families reported speaking a language other than English in the home less than 20% of the time.

Table 4

*Characteristics of Mothers of High- and Low-Risk Infants.*

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>High Risk Infants $(n = 8)$</th>
<th>Low Risk Infants $(n = 9)$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (years)</strong></td>
<td>M (SD)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>37.26 (3.03)</td>
<td>32.43 (2.77)</td>
</tr>
<tr>
<td></td>
<td>Min–Max</td>
<td></td>
</tr>
<tr>
<td></td>
<td>33.25–41.58</td>
<td>27.83–36.08</td>
</tr>
<tr>
<td><strong>Level of Education</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade school/high school</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>College/some University</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>University Degree</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Graduate Degree</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td># homes where another language was</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>spoken &lt;20% of the time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BDI-II</td>
<td>M (SD)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11.00 (5.04)</td>
<td>4.22 (2.9)</td>
</tr>
<tr>
<td></td>
<td>Min–Max</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0–18</td>
<td>1–8</td>
</tr>
<tr>
<td>SRS</td>
<td>M (SD)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.63 (6.28)</td>
<td>9.67 (6.21)</td>
</tr>
</tbody>
</table>
Min–Max  4–24  1–17

Note. BDI-II = Beck Depression Inventory – Second Edition (Total Score; where 0–13: minimal depression; 14–19: mild depression; 20–28: moderate depression; 29–63 severe depression).

SRS = Social Responsiveness Scale – Adult Research Version (Total Score; ranging from 0 (highly socially competent) to 195 (severely socially impaired). Scores above 60 indicate clinically significant deficits in reciprocal social behaviour.

Mothers of high-risk infants reported significantly more symptoms of depression than mothers of low-risk infants as indicated by higher scores on the Beck Depression Inventory - Second Edition (BDI-II; Beck, Steer, & Brown, 1996), $z = -2.61, p = .009, d = .63$. The BDI-II is a standardized, self-report questionnaire that evaluates the presence and severity of depression symptoms. There were no significant group differences on the Social Responsiveness Scale – Adult Research Version (SRS; Constantino & Gruber, 2005), $t(15)=.316, p=.756$. This measure assesses reciprocal social behaviour, social communication, and restricted and repetitive behaviours or interests. These measures and the rationale for their use are described more fully in a later section.

Family sizes in the high-risk group varied: one infant had one older sibling, 5 infants had 2 older siblings, one infant had 4 older siblings, and one infant had one older half sibling. The mean age of the proband in the high-risk group was 64.1 months. All 9 infants in the low-risk group had only one older sibling (mean age = 28.3 months).

Table 5 outlines the ethnic backgrounds of mothers in both groups. The majority of mothers in both groups were Caucasian, 2 mothers in each group were of Asian heritage and one mother in the high-risk group was of African heritage.
Table 5

*Ethnic Backgrounds of Mothers with High- and Low-Risk Infants.*

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Mothers of High-risk Infants (n=8)</th>
<th>Mothers of Low-risk Infants (n=9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caucasian</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Asian Heritage</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>African Heritage</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

**Procedure**

As part of the larger, longitudinal study, all infants attended a 12-month visit at the Autism Research Unit, Hospital for Sick Children (Sick Kids), Toronto (see Figure 1). Following the 12-month visit, high-risk infants who met inclusion criteria (i.e., had six or more risk markers on the AOSI) were invited to take part in the current study. All low-risk infants were also invited to participate following the 12-month visit. A brief description of the current study was provided to both groups of mothers by a research assistant employed by the longitudinal study. The investigator obtained informed consent from each of the families at the time of first contact with the family.
Figure 1. Recruitment and Procedures.

Mothers of low-risk infants who consented to participate were asked to complete the Communication and Symbolic Behavior Scales Developmental Profile – Infant-Toddler Checklist (CSBS-DP; Wetherby & Prizant, 2002), a questionnaire that evaluated their infants’ early communication development. The results of this questionnaire were used to exclude infants with communication delays. Infants who received cut-off scores below normal for their age in any of the three composite domains (social, speech, and symbolic) of the CSBS-DP Infant-Toddler Checklist were provided with feedback and given information regarding how to contact Preschool Speech and Language Services.

Setting and Apparatus

All infant–mother dyads participated in two sessions: a home visit session and a clinic-based assessment session. In order to minimize any influence of the
clinician’s interaction style on the mothers’ interaction style, every attempt was made to schedule the home visit prior to the clinic visit. However, this was not always possible due to infant illness or scheduling conflicts in both groups. Three infants in the low-risk group and two infants in the high-risk group had clinic visits prior to home visits.

Home Visit. When possible, the home visit took place prior to the 15-month clinic-based visit that was scheduled by the longitudinal, early identification study. The home visit consisted of a short orientation that included (a) a review of the general purpose and procedures of the study, (b) an overview of how the home visit would be conducted, and (c) instructions for infant–mother play activities (see Appendix A). Six play activities were chosen to sample all types and communicative functions of gestures. Materials were provided for the play interaction. Mothers were asked to engage their infants in all six, naturalistic activities for approximately two minutes per activity, resulting in an approximate videotape length of 14–18 minutes of infant–mother play interaction.

Three activities took place with the infant seated in a highchair and included a choice of two songs (“Itsy Bitsy Spider” or “Wheels on the Bus”), a book (“Pat the Bunny”), and a transparent container containing a wind-up toy. Highchair placement was decided by the mother to ensure the most naturalistic setting. The highchair was typically located in or near the kitchen with the mother seated on a kitchen chair across from or on a 90-degree angle to the infant. Toys for the highchair activities were placed on the kitchen table or nearby counter in view of the infant and the mother. Mothers were asked to engage their infant in the three activities in any order that was comfortable for them.

Three activities took place on the floor and included a set of pretend play toys (a baby doll, 2 spoons, 2 cups, 2 plates, a hairbrush, a facecloth, a baby bottle, and a blanket), a social game (“Peek-a-boo”), and a novel toy (a mechanical baby duck that made quacking sounds and a baby bottle for the duck). Mothers were asked to choose the area where they played most commonly with their infants. This was typically the living room or a basement playroom. Toys for the floor activities were placed near the mother and covered with the blanket used for the “peek-a-
Mothers were asked to engage their infant in the three activities in any order that was comfortable for them. Highchair and floor play activities were counterbalanced across participants to address possible confounding factors such as fatigue and motivation.

The investigator conducted the videotaping with the camera in hand in order to allow for mobility while following the interactions. During the highchair activities the investigator stood 3–6 feet from the infant/mother dyad. During the floor activities the investigator was seated on the floor 3–6 feet from the infant mother–dyad. The home visit yielded an 8–16 minute videotape from which the following data for infants and mothers were derived: (a) the number of infant gestures and symbolic play actions and, (b) the number of maternal gestures, (c) the number of maternal gesture-related behaviours, and (d) the number of symbolic play actions.

At the conclusion of the home visit, mothers were asked to complete a questionnaire to evaluate whether their infants’ communication and play behaviour during their play interaction had been representative of their typical interaction behaviour. The Communication and Symbolic Behavior Scale – Developmental Profile: Caregiver Perception Rating Scale (CSBS-DP: CRS; Wetherby & Prizant, 2002) was used. This questionnaire, which appears in Appendix B, asks mothers to rate their infants’ behaviour on a 3-point scale for seven items (where 1 represented infant behaviour as being “less” or “worse” than typical, 2 represented infant behaviour that was typical, and 3 represented infant behaviour that was “more” or “better” than typical for the infant). The 7 items on this scale included (a) alertness, (b) emotional reaction, (c) level of interest and attention, (d) comfort level, (e) level of activity, (f) overall level of communication, and (g) play behaviour. Total scores could range from 7 (i.e., least typical) to 21 (i.e., better than typical). The mean scores of the Caregiver Perception Rating Scale for infants in the high- ($M = 12.75, SD = 1.28$) and low-risk ($M = 12.56, SD = 1.51$) groups indicated that mothers in both groups rated their infants’ interaction behaviour as broadly typical. A Mann-Whitney $U$ test was conducted to determine whether there were group differences in the interaction behaviour of their infants. The test was not significant $z = -.251, p$
indicating that there were no group differences in the way mothers perceived their infants’ interaction behaviour in the home context.  

**Clinic Visit.** The clinic-based assessment session took place during the 15-month visit scheduled by the longitudinal, early identification study. Consequently the 15-month visit was approximately 20 minutes longer for the participants in this study relative to the participants in the longitudinal study. This session included a clinician-administered measure of prelinguistic communication and symbolic behaviour of each infant (Communication and Symbolic Behaviour Scales DP–Behavior Sample: CSBS-DP; Wetherby & Prizant, 2002). This instrument was administered in the standardized manner, digitally recorded, and later scored from video. Typically, this measure is coded from video using standard scoring procedures designed for clinical use. However, the standard scoring procedures were not used. Rather, all gestures behaviours were counted in order to obtain a more precise measure of infant gesture types and their functions (Shumway & Wetherby, 2009). At the conclusion of the clinic visit, mothers were also asked to complete the CSBS-DP: CRS (Wetherby & Prizant, 2002) to evaluate whether their infants’ communication and play behaviour was representative of their typical interaction behaviour during the clinic visit (see Appendix C). The mean scores of the Caregiver Perception Rating Scale for infants in the high- \((M = 12.00, SD = 2.27)\) and low-risk \((M = 12.22, SD = 2.11)\) groups indicated that mothers in both groups rated their infants’ interaction behaviour as broadly typical. A Mann-Whitney \(U\) test was conducted to determine whether there were group differences in the interaction behaviour of the infants. The test was not significant \(z = -1.195, p = .846\), indicating that there were no group differences in the way mothers perceived their infants’ interaction behaviour in the clinical context.

Mothers in both groups were given three questionnaires. First, the MacArthur-Bates Communicative Development Inventory – Words and Gestures (MCDI-WG; Fenson et al., 1993) was used to obtain an inventory of their infants’ use of gestures and early receptive and expressive vocabulary. This questionnaire was included with the 15-month package mailed to families as part of the longitudinal study prior to their 15-month clinical visit. Second, the Beck Depression Inventory –
BDI-II (Beck et a., 1996) was given to the mothers during their first contact with the investigator. Mothers whose scores were at or above the cut-off for depression were contacted by telephone and offered a referral to their family physician or a mental health resource for further assessment and consultation. The telephone script used is in Appendix D. This procedure and the telephone script was approved by the Research Ethics Board at the Hospital for Sick Children (Sick Kids). Third, the Adult Research version of the Social Responsiveness Scale (SRS; Constantino & Gruber, 2005) was given to measure reciprocal social behaviour, social communication, and restricted and repetitive behaviours or interests of the mothers. The questionnaire was completed by a spouse or another adult who knew the mother well. The completed questionnaires were collected at the second contact session or returned via mail.

To ensure that infants had no known hearing loss, information regarding the status of infants’ hearing was obtained or evaluated directly. According to parent report, all infants passed a newborn infant hearing screening conducted by the Ontario Ministry of Children and Youth as part of Ontario’s Infant Hearing Program (IHP). Additionally, at least two attempts were made to conduct hearing screenings for infants (i.e., either at their 15-month clinic visit or at their home assessment session) using Distortion Product Acoustic Emissions (DPOAE) testing (AuDX Biologic Systems Corporation). As a speech-language pathologist registered with the College of Audiologists and Speech-Language Pathologists of Ontario the investigator was qualified to conduct the hearing screenings. In addition to clinical qualifications, the investigator was trained in the administration of AOAE screening by a clinician from the IHP in Toronto. In the high-risk group, four infants passed this additional hearing screening in at least one ear, two infants passed a full audiological assessment completed by an audiologist, two infants were non-compliant for hearing screening and referred for audiological evaluation. It was not possible to obtain further information regarding the outcome of these two evaluations. In the low-risk group, five infants passed the additional hearing screening, one infant failed the hearing screening and was referred for an audiological evaluation, which resulted in normal hearing being assessed bilaterally.
Three infants were non-compliant and referred for audiological evaluation. It was not possible to obtain further information regarding the outcome of these evaluations.

**Independent Variables**

**Autism Observation Scale for Infants.** The Autism Observation Scale for Infants (AOSI; Bryson et al., 2008) was administered by a research assistant from the longitudinal study. This measure is a semi-structured, direct-observation tool designed to identify and rate the occurrence or non-occurrence of behavioural indicators of risk for ASD in infants aged 6 to 18 months. Infant behaviour was rated for each of 16 items. Scores range from 0 to 3 for each item; a score of 0 implies typical behaviour and higher scores indicate increasing deviation from typical behaviour. Inter-rater reliability for the total number of markers and total scores was shown to be excellent ($r = .92$ and $.93$ respectively) at 12 months of age. Test-retest reliability at 12 months was also within acceptable limits for total marker counts and total score ($r = .68$ and $.61$ respectively; Bryson et al., 2008). Infants with scores of 9 or more at 12 months of age were most likely to meet diagnostic criteria for autism spectrum disorder at age 3 (Brian et al., 2008; Zwaigenbaum et al., 2008).

**Communication and Symbolic Behavior Scales Developmental Profile – Infant-Toddler Checklist.** The Communication and Symbolic Behavior Scales Developmental Profile – Infant-Toddler Checklist (Wetherby & Prizant, 2002; CSBS-DP) is a developmental screening measure designed to identify infants at risk for developing communication impairment (Wetherby, Allen, Cleary, Kublin & Goldstein, 2002; Wetherby Goldstein, Cleary, Allen & Kublin, 2003) and was administered by a research assistant from the longitudinal study. It was used to provide information regarding infants’ prelinguistic development in the low-risk group. The checklist, completed by a parent, contains 24 questions distributed across 7 subscales (Emotion and Eye Gaze, Communication, Gestures, Sounds, Words, Understanding, Object Use). Responses are clustered into three composite domains: (a) social, (b) speech, and (c) symbolic behaviour. A validation study examining the predictive validity of this measure indicated it had good sensitivity (86%) and specificity (75%) as a screening tool for identifying infants aged 12–17
months who are likely to have a communication impairment (Wetherby et al., 2003). Further, this parent-report measure predicted receptive \( r = .59 \) and expressive \( r = .57 \) language outcomes on the MSEL (MSEL; Mullen, 1995) at age two.

**Mullen Scales of Early Learning.** The *Mullen Scales of Early Learning* (MSEL; Mullen, 1995) is an individually administered, standardized measure of cognitive functioning in young children from birth to 68 months of age. This measure was administered by a research assistant from the longitudinal study. It consists of four cognitive scales (Visual Reception, Receptive Language, Expressive Language, and Fine Motor) and one gross motor scale (administered up to the age of 33 months). Performance on each scale is reported as a T-score \( (M = 50, SD = 10) \). T-scores from the four cognitive scales yield an Early Learning Composite score, which is considered to be an overall estimate of cognitive functioning.

Psychometric properties of the measure are reported in the manual (Mullen, 1995). For the purposes of this study, internal consistency is reported for the Early Learning Composite of the measure for the 11–12 month age range only. The split-half consistency coefficient for the Early Learning Composite for the 11–12 month age level was \( r = .92 \). Test-retest reliability for the 0 to 24 month age range for each subdomain was as follows: Gross Motor, \( r = .96 \), Visual Reception \( r = .85 \), Fine Motor \( r = .83 \), Receptive Language \( r = .82 \), and Expressive Language \( r = .85 \). Concurrent validity of the MSEL Early Learning Composite with the *Bayley Scales of Infant Development* (BSID; Bayley, 1969) Mental Development Index was \( r = .70 \). The BSID is a standardized measure of motor, language, and cognitive development in infants from birth to three years of age.

**Social Responsiveness Scale.** The adult research version of the *Social Responsiveness Scale* (SRS; Constantino & Gruber, 2005) is a 65-item questionnaire designed to measure reciprocal social behaviour, social communication, and restricted and repetitive behaviours or interests. The questionnaire is completed by a spouse or other adult who knows the targeted adult well. An earlier child and adolescent version was normed on a sample of 250 children 4 to 18 years of age (Constantino, Przybeck, Friesen, & Todd 2000; Constantino et al., 2003a;
The child version shows good internal consistency (Chronbach’s α = .93 and .94 for males and females respectively; Constantino & Gruber, 2005). Test-retest reliability is reported as $r = .83$ (Constantino & Gruber, 2005). The measure shows good concurrent validity with the *Autism Diagnostic Interview – Revised* (ADI-R; Lord, C., Rutter, M., & Le Couteur, A. 1994) a parent-report clinical interview used to determine diagnostic classifications of autism. Correlations between SRS scores and ADI-R algorithm subdomains (i.e., qualitative impairments in reciprocal social behaviour, delays in language development, and restricted range of interests and/or stereotypic behaviours) ranged from $r = .67$ to $r = .77$ (Constantino et al., 2003a). Although the adult research version has not yet been normed, it differs from the child version in only 13 questions (i.e., questions have been reworded in order to be developmentally appropriate for adults). Moreover, because scores obtained from the younger sample were not related to age and did not vary as a function of race, ethnicity, or education level of the rater, the adult research version was expected to have similar sensitivity and specificity to the normed version for evaluating the constructs measured (Constantino et al., 2000, 2003a; Constantino & Todd 2000, 2005; Ho et al., 2005). This measure yields raw scores that can range from 0 (highly socially competent) to 195 (severely socially impaired). A score greater than 60 on this measure indicates clinically significant deficits in reciprocal social behaviour. This measure was used in the current study to evaluate maternal social interaction behaviours because many cases of autism can be attributed to genetic heritability (Lauritsen et al., 2005), specifically the heritability of reciprocal social communication deficits seen in ASD (Constantino, Hudziak, & Todd, 2003b; Constantino & Todd, 2000).

**Beck Depression Inventory.** The *Beck Depression Inventory-Second Edition* (BDI-II; Beck et al., 1996) is a 21-item self-report instrument that assesses the presence and severity of symptoms of depression in the Diagnostic and Statistical Manual of Mental Disorders-Fourth Edition (DSM-IV; 1994). It has been widely used in standard practice by healthcare professionals as an assessment tool to
differentiate between depressed and non-depressed adolescents and adults (Richter, Werner, Heerlein, & Sauer, 1998). The BDI-II has strong correlations with other measures of depression symptoms. Sprinkle et al. (2002) reported that scores on the BDI-II were strongly correlated \( r = .83 \) with symptoms reported in the Structured Clinical Interview for Diagnostic and Statistical Manual of Mental Disorders-Fourth Edition (American Psychiatric Association, 1994). Sprinkle et al. (2002) determined the sensitivity of a cut-off score of 16 to be 84% and 18% false positives. In addition, authors reported good test-retest correlation \( r = .96 \), which is comparable to the test-retest correlation \( r = .93 \) reported in the manual (Beck et al., 1996). When completing the inventory, the person is asked to rate each statement on a four-point scale (0–3) as it relates to how they have felt in the previous two weeks. Two items are rated using seven options to address changes in sleep and appetite. Items are summed to obtain a total score. Cut-off scores are 0–13: minimal depression; 14–19: mild depression; 20–28: moderate depression; 29–63 severe depression. The questionnaire contained an item asking about Suicidal Thoughts or Wishes (Item 9). This item was deleted because effective and timely response to reported suicide risk was not possible. The cut-off score corresponding to moderate depression is 20. However, since Item 9 was removed, a cut-off score equal to or greater than 17 was used.

**Dependent Variables (measures)**

The Communication and Symbolic Behaviour Scales DP– Behavior Sample (CSBS-DP; Wetherby & Prizant, 2002) is a norm-referenced assessment measure designed to evaluate the communicative competence (use of eye gaze, gestures, sounds, words, understanding, and play) of children aged 6 to 24 months. This semi-structured, videotaped assessment is conducted by a clinician with a parent present and takes 30 minutes to administer. The measure consists of play activities and the use of strategies designed to elicit spontaneous social communication behaviours. Conventionally, behaviours are reviewed on videotape and scored according to a standardized scoring system designed to rate: (a) communicative function (e.g., joint attention, behaviour regulation and social interaction), (b) communicative means (e.g., gestural, vocal, verbal), (c) reciprocity, (d) social-affective signaling (e.g.,
sharing enjoyment), and (e) symbolic behaviour (e.g., play and use of objects). The standardized administration procedures were followed; however, infant gestures were coded using the coding system developed for the study (see Appendix E). Psychometric properties of this measure are therefore not reported here. This measure was administered and scored from videotape by the investigator, who is a registered speech-language pathologist.

The MacArthur-Bates Communicative Development Inventory – Infant Form Words and Gestures (MCDI-WG; Fenson et al., 1993) was used to obtain parent report of infant communication and inventory use of gesture and receptive and expressive vocabulary. The MCDI-WG catalogues children’s use of communicative and symbolic play gestures. Two variables, namely, early gestures (e.g., communicative) and late gestures (e.g., symbolic play) were used. Reliability and validity for all subscales of the MCDI-WG were established in a large-scale standardization study (n = 659; Fenson et al., 1994). Internal consistency for the gesture subscales was reported as Chronbach’s α = .79. Test-retest reliability for gesture scores was reported as r = .80. Concurrent validity for the gesture subscales was not examined relative to other standardized measures of language. This measure was scored by a trained research assistant as part of the data collected for the longitudinal, early identification study.

Coding Procedures

Coding procedures were developed using adaptations of gesture taxonomies described in the literature (e.g., Bruner, 1981; Crais et al., 2004; Iverson & Thal, 1998). Codes for describing the gesture strategies that mothers used to augment their spoke language were adapted from Iverson et al. (1999). The complete coding manual appears in Appendix F.

All infant gestures and symbolic play acts were coded from two sources: (a) a home videotape of mother-infant play activities, and (b) a clinic videotape of the CSBS-DP, which the investigator administered. In the home context, infant-mother dyads participated in six naturalistic play activities, which were videotaped to evaluate the use of gestures and symbolic play acts in infants and mothers. Infant
gestures were coded for directedness (i.e., directed or non-directed) and type (i.e., deictic, conventional, or representational). Directed gestures were also coded for communicative function (i.e., behaviour regulation, social interaction, or joint attention). Play actions produced by infants were coded as symbolic play acts. In the clinic context, infants were videotaped during their participation in the administration of the CSBS-DP (Whetherby & Prizant, 2002). This measure was not scored in the standardized way; rather, gestures and symbolic play acts were coded from videotape with the same coding procedures used for the clinic context. A description of each infant code with accompanying examples is provided in Table 6.

Table 6

**Descriptions and Examples of Infant Codes**

<table>
<thead>
<tr>
<th>Gesture Codes</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deictic</td>
<td>Signal a specific referent by differentiating it from other referents in the environment</td>
<td>POINT to an object/person, SHOW or GIVE an object to a person, REACH for an object</td>
</tr>
<tr>
<td>Conventional</td>
<td>Indicate semantic content with no specific object referenced</td>
<td>NOD (e.g., nods head “Yes”), INDEX FINGER ON MOUTH for “Shhh,” ARMS OUT TO SIDE for “Where?” or “I don’t know”</td>
</tr>
<tr>
<td>Representational</td>
<td>Refer to objects, persons, or events, and represent attributes or actions performed with or by their referents (also known as iconic gestures) and include ASL signs</td>
<td>ARMS OUT TO SIDE for “airplane,” CLAW SHAPED HAND for “tiger,” BLOW with mouth for “blow,” DRAW CIRCLE WITH HAND OR FINGER for “spin” or “round and round”</td>
</tr>
<tr>
<td>Directedness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Directed</td>
<td>Gesture is directed to a communication partner</td>
<td>Gesture produced: while looking at a person or</td>
</tr>
<tr>
<td>Category</td>
<td>Description</td>
<td>Example</td>
</tr>
<tr>
<td>--------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Non-directed</td>
<td>Gestures produced but without evidence of directedness</td>
<td>POINT to an object without looking at communication partner, ARMS OUT for “Where?” but not coordinated with vocalization</td>
</tr>
<tr>
<td>Communicative Function</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Behaviour</td>
<td>Purpose of the gesture is to regulate the behaviour of another person</td>
<td>Gestures used to request (e.g., demand an object), direct, e.g., (command another person to carry an action), protest (e.g., refuse an undesired object)</td>
</tr>
<tr>
<td>Regulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Interaction</td>
<td>Purpose of the gesture is to draw another person’s attention to oneself</td>
<td>Gestures used to request a social routine, show off, greet, call to, acknowledge a person, request permission or comfort</td>
</tr>
<tr>
<td>Joint Attention</td>
<td>Purpose of the gesture is to direct another person’s attention to an object or event in order to get the person to notice something of interest</td>
<td>Gestures used to comment (e.g., SHOW an object of interest), request information (e.g., ARMS OUT to ask “Where?”) or clarification (e.g., POINT to ask “Here?”)</td>
</tr>
<tr>
<td>Symbolic Play Acts</td>
<td>An appropriate action with a toy in isolation or toward an agent (e.g., mother, doll etc.)</td>
<td>Stir with spoon, drink from cup, brush doll’s hair, feed Elmo with spoon, scoop with spoon from plate, rock baby,</td>
</tr>
</tbody>
</table>
Note. Capital letters denote the gesture produced while quotations denote the meaning of the gesture.

Maternal gestures, maternal symbolic play acts, and other maternal behaviours related to gestures were coded in the home context only. Mothers’ gestures and symbolic play acts were coded with the same codes used used for infants (with the exception of directedness). Two additional maternal categories captured: (a) gesture strategies that mothers used to augment their spoken language (emphasize, disambiguate, and add) and (b) prompts used to encourage infant gesturing (model, verbal, and physical). A description of each additional code used for mothers with accompanying examples is provided in Table 7. Codes, descriptions of codes, and examples for gesture type and function do not appear in Table 7 as they are the same as those used for infants.

Maternal behaviours were coded for: (a) gesture type (i.e. deictic, conventional, or representational), (b) gesture function (i.e., behaviour regulation, social interaction, or joint attention), (c) use of prompts used to encourage infant gesturing were coded (i.e., model, verbal, and physical); (d) maternal gesture strategies used to augment their spoken language (i.e., emphasize, disambiguate, or add). Play actions produced by mothers were coded as symbolic play acts.

Table 7

Descriptions and Examples of Codes for Mothers

<table>
<thead>
<tr>
<th>Codes</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gesture strategy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emphasize</td>
<td>Gesture serves to</td>
<td>Conventional gesture paired with verbal equivalent (e.g., NOD + “Yes”, deictic gesture paired with label of the referent (e.g., POINT to car + “I see that car”)</td>
</tr>
<tr>
<td></td>
<td>reinforce the verbal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>utterance</td>
<td></td>
</tr>
<tr>
<td>Disambiguate</td>
<td>Gesture serves to</td>
<td>Deictic gesture paired with a</td>
</tr>
</tbody>
</table>
disambiguate the verbal utterance by identifying the precise referent (when the referent is not labeled) 

demonstrative or locative expression (e.g., POINT to Elmo + “There he is,” deictic gesture paired with expression to direct attention (e.g., POINT + “Look”)

Add Gesture serves to add information (i.e., the referent) to verbal utterance (gesture and language contribute unique information)

Deictic gesture paired with expression with semantic content (e.g., SHOW car + “Are you all done?”

Prompt type

Model

Demonstration of the gesture serves to encourage the infant to produce the same gesture

Production of a gesture followed by time delay, looking expectantly at infant, repeating the gesture, production of the gesture is paired with a verbal prompt

Verbal

Mother verbally directs the infant to produce the gesture

Mother says “Wave bye-bye,” mother models PEEK-A-BOO gesture and says “You do it”

Physical

Mother physically manipulates the infant’s body to produce the gesture

Mother takes infant’s hand and moves it up and down in BYE-BYE gesture

*Note. Capital letters denote the gesture produced while quotations denote words produced as verbal utterance.*
Reliability

Inter-rater reliability was calculated using percentage agreement and Cohen’s kappa coefficients for approximately 20% of the home and clinic videos. Eight videos were randomly selected from each group and context (two high-risk and two low-risk infants in the clinic context, and two high-risk infant-mother dyads and two low-risk infant-mother dyads in the home context). A research assistant who had completed a Communication Disorders Assistant (CDA) program at a community college was trained to use the coding system. The CDA received 20 hours of training to code infant behaviours and 12 hours of training to code maternal behaviours. Training included an overview of code definitions for infants and mothers. In addition, of the videos that were not randomly selected for inter-rater reliability, three were coded side-by-side with the research assistant until consensus reliability reached 90%. The CDA was blind to group membership.

Inter-rater reliability was conducted separately for infants and mothers and yielded two measures of reliability. First, to determine agreement between the two raters with respect to total behaviours coded, percentages of agreement were calculated to reflect whether a behaviour identified to be coded by one coder was also coded by the second coder. Percentages of agreement for total gesture behaviours coded and total symbolic play acts coded for infants in clinic and home contexts appear in Table 8. Percentage agreement for total gestures and related behaviours coded and total symbolic play acts coded for mothers appear in Table 8. Second, behaviours identified for coding were assigned a code. For infant behaviours, Cohen’s kappa was calculated for: (a) gesture type, (b) directedness, and (c) communicative function. For maternal behaviours, Cohen’s kappa was calculated for: (a) gesture type, (b) communicative function, (c) prompts, and (d) how gestures augmented maternal language.
Table 8


<table>
<thead>
<tr>
<th>Behaviours Identified for Coding</th>
<th>Percentage Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant Gesture Behaviours</td>
<td></td>
</tr>
<tr>
<td>Clinic</td>
<td>86.12%</td>
</tr>
<tr>
<td>Home</td>
<td>90.10 %</td>
</tr>
<tr>
<td>Infant Symbolic Play Acts</td>
<td></td>
</tr>
<tr>
<td>Clinic</td>
<td>98.28%</td>
</tr>
<tr>
<td>Home</td>
<td>94.44%</td>
</tr>
<tr>
<td>Mothers’ Gestures and Related</td>
<td></td>
</tr>
<tr>
<td>Behaviours</td>
<td>91.50 %</td>
</tr>
<tr>
<td>Mothers’ Symbolic Play Acts</td>
<td>82.22%</td>
</tr>
</tbody>
</table>

Cohen’s kappa values between .40 and .60 indicate fair agreement, values between .60 and .75 indicate good agreement, and values over .75 indicate excellent agreement (Fleiss, 1981). Table 9 shows percentage agreement and Cohen’s kappa results for infant gestures by directedness, type, and functions for clinic and home contexts. Table 10 shows percentage agreement for: (a) maternal gestures by type and function, (b) maternal prompts, and (c) the maternal gesture strategy used to augment spoken language. Inter-rate reliability measures indicate excellent agreement overall.
Table 9

*Reliability Coefficients and Percentage Agreement for Infant Gestures (Clinic and Home Contexts).*

<table>
<thead>
<tr>
<th>Directedness</th>
<th>Code</th>
<th>Cohen’s kappa (κ)</th>
<th>Percentage Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinic</td>
<td>.85</td>
<td>94.49%</td>
<td></td>
</tr>
<tr>
<td>Home</td>
<td>.86</td>
<td>94.72%</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Clinic</td>
<td>.98</td>
<td>98.75%</td>
</tr>
<tr>
<td></td>
<td>Home</td>
<td>.98</td>
<td>99.18%</td>
</tr>
<tr>
<td>Function</td>
<td>Clinic</td>
<td>.85</td>
<td>90.23%</td>
</tr>
<tr>
<td></td>
<td>Home</td>
<td>.95</td>
<td>98.00%</td>
</tr>
</tbody>
</table>

Table 10

*Percentage Agreement and Reliability Coefficients for Mothers’ Gestures, Prompts, and Gesture Strategy to Augment Spoken Language.*

<table>
<thead>
<tr>
<th>Dependent Variable (code)</th>
<th>Cohen’s kappa (g)</th>
<th>Percentage Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>.98</td>
<td>99.09%</td>
</tr>
<tr>
<td>Function</td>
<td>.94</td>
<td>96.73%</td>
</tr>
<tr>
<td>Maternal prompts</td>
<td>.89</td>
<td>90.54%</td>
</tr>
<tr>
<td>Gesture strategy to augment language</td>
<td>.90</td>
<td>96.31%</td>
</tr>
</tbody>
</table>
Results

This section addresses the series of research questions in the order they were presented in the Method section. Group comparisons of infant gestures and symbolic play acts in the clinic and home context are thus reported first. Presented second are results comparing mothers’ use of gestures, symbolic play acts, and behaviours related to gestures. Presented third is a comparison of parent-reported gesture use in infants.

The research questions pertaining to infants were addressed by comparing high- and low risk infants on: (a) the rate of overall gesture use (i.e., directed and non-directed), (b) the profile of types of gestures (i.e., rate of deictic, conventional, and representational gestures), (c) the profile of communicative functions of gestures (i.e., the rate of gestures used for behaviour regulation, social interaction, joint attention), and (d) the rate of symbolic play acts.

A special application of a repeated-measure MANOVA (profile analysis; Tabachnik & Fidell, 2007) was selected as the most appropriate statistical model to address questions regarding directed and non-directed gestures, type, and function of gestures. Clinic and home contexts were examined separately because variability across contexts may prevent meaningful interpretation of infant gesture differences. Sources of variability in infant behaviours may be due to several factors. For example, infant interaction with the clinician may differ from that with the mother due to comfort level or infant behaviour may differ in unfamiliar and familiar contexts. Differences in infant behaviour may also be due to the fact that activities were not identical in both contexts (i.e., the clinic context included a standardized administration of play activities whereas the home context included six naturalistic play activities).

For all analyses, an alpha level of .05 was employed. Effect sizes for profile analyses were reported as partial eta squared ($\eta^2$) where .01, .06, and .14 are considered small, medium, and large effect sizes respectively (Green & Salkind, 2003). Simple effects contrasts included parametric independent samples and paired-samples t tests. Where appropriate, non-parametric Mann-Whitney U and
Wilcoxon Signed Ranks tests were conducted. Effect sizes for parametric tests were reported as Cohen’s $d$ where .2, .5, and .8 are considered small, medium, and large effect sizes respectively (Cohen, 1992). Effect sizes for non-parametric tests were reported as Pearson’s $r$ where .10, .30, and .50 are considered small, medium, and large effect sizes respectively (Cohen, 1988).

Profile analysis is a special application of repeated-measures MANOVA. Profile analysis has two applications: it can be used to compare group means on a set of dependent variables over several time points, or it can be used to compare group means of several dependent variables measured on the same scale. The primary analyses used in this study compared group means of several dependent variables (i.e., measures) all measured on the same scale. The scale used in this study was rate per minute. Typically, in MANOVA, the group mean of each dependent variable is used for comparison; in profile analysis the difference between the mean of the first and second measure of the dependent variable, and then the difference between the second and third measure of the dependent variable etc., are used for comparisons. Each difference is referred to as a segment. Segments, rather than mean scores, are thus used for the main group comparisons in profile analysis. However, individual group means are used for $a$ priori and post-hoc analyses.

Profile analysis addresses three questions: (a) do groups have parallel profiles across the collected set of measures of the dependent variable (i.e., parallelism), (b) if the profiles are parallel, are the groups at equal levels across the collected set of measures of the dependent variable (i.e., is one group higher or lower on average across the observations), and (c) are the measures for each dependent variable the same (i.e., flatness) regardless of group? If the profiles compared are not parallel (i.e., different), simple-effects contrasts are performed to pinpoint sources of difference. Simple-effects contrasts can include a comparison of group means for one or more measures (between-group comparison) and/or a comparison of measures within a group (within-group comparisons).

Infant symbolic play acts were examined using independent samples $t$ tests for each context (i.e., clinic and home) separately. The data for parent-reported
gestures were count data and reflected an inventory of infant gestures as reported by the mothers. Group comparisons for parent-reported gestures were therefore examined using independent samples t tests.

Additional research questions in this study pertain to mothers and will be presented second. Mothers of high- and low-risk infants were compared with respect to: (a) the rate of gesture use, (b) the profile of types of gestures (i.e., the rate of deictic, conventional, and representational gestures used), (c) the profile of communicative functions of gestures (i.e., the rate of gestures used for behaviour regulation, social interaction, and joint attention), (d) the rate of use of symbolic play acts, e) the profile of prompts used to encourage infant gesturing (i.e., the rate of models, verbal prompts, and physical prompts), and (f) the profile of gesture strategies used to accompany maternal language (i.e., the rate of gestures that served to emphasize, disambiguate, and add to spoken language).

Rates of maternal gestures were compared using independent samples t tests, as were rates of symbolic play acts. Profile analysis was selected as the most appropriate statistical model to address research questions regarding the type and function of gestures as well as the maternal gesture strategies used to augment spoken language. Although data were collected to investigate prompts used by mothers to encourage infant gesturing (model, verbal, physical), the very low frequency of use of each prompt necessitated collapsing the data into one dependent variable (i.e. rate of prompting) which was then analyzed using an independent samples t test.

As part of the longitudinal study, diagnostic status assessments for all infants were conducted at 24 months of age by expert clinicians using the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavore, & Risi, 1999) together with clinical judgment. Of the eight high-risk infants, seven met criteria for a diagnosis of an autism spectrum disorder at 24 months of age. One high-risk infant met criteria for language delay. No infants in the low-risk group met criteria for ASD or language delay.
Infants

Directed and non-directed gesture use. The first question of this study asked whether high-risk infants had the same overall rate of gesture use as low-risk infants. The “rate of gesture use,” conforms to the conventional definition of a gesture in the current literature (i.e., an action produced with the hands, arms, fingers, body, or face that is directed to a person and serves a communicative function). Thus, gestures directed to a person are referred to as directed gestures. In addition, non-directed gestures (i.e., actions produced with the hands, arms, fingers, body, or face but that are not directed to a person) were examined. The dependent variables (i.e., directed and non-directed gesture rates) for this analysis were examined in a clinic and a home context separately. Means and standard deviations for directed and non-directed gestures rates in clinic and home contexts are presented in Table 11.

Table 11

Means and Standard Deviations for Directed and Non-Directed Gestures in Clinical and Home Contexts by Group

<table>
<thead>
<tr>
<th>Gestures</th>
<th>High-Risk Infants (n = 8)</th>
<th>Low-Risk Infants (n = 9)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td></td>
</tr>
<tr>
<td>Directed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinic</td>
<td>2.60 (1.30)</td>
<td>4.22 (.93)</td>
</tr>
<tr>
<td>Min–Max</td>
<td>1.11–4.54</td>
<td>2.82–5.60</td>
</tr>
<tr>
<td>Home</td>
<td>2.10 (.89)</td>
<td>3.73 (.85)</td>
</tr>
<tr>
<td>Min–Max</td>
<td>1.12–4.03</td>
<td>2.60–5.18</td>
</tr>
<tr>
<td>Non-directed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinic</td>
<td>2.40 (.97)</td>
<td>1.17 (.47)</td>
</tr>
<tr>
<td>Min–Max</td>
<td>1.18–3.93</td>
<td>.55–2.11</td>
</tr>
<tr>
<td>Home</td>
<td>2.27 (.84)</td>
<td>1.22 (.72)</td>
</tr>
<tr>
<td>Min–Max</td>
<td>.86–3.74</td>
<td>.36–2.53</td>
</tr>
</tbody>
</table>
Clinic context.

Between-group comparison of profiles of directedness of gestures. To investigate the hypothesis that high- and low-risk infants have different profiles of directed and non-directed gesture use in a clinic context, a profile analysis was conducted to examine directedness of gestures. The independent variable was group (i.e., high- and low-risk). The dependent variable was gesture directedness (i.e., mean rates of directed and non-directed gestures in a clinic context). Mean rates of directed and non-directed gestures were normally distributed for both groups in the clinic context. However, the assumption of homogeneity of variance was violated for non-directed gestures. The covariance matrices for the dependent variables were equal across groups. The profiles of directed and non-directed gestures for each group in the clinic context appear in Figure 2. Using the Wilks-Lambda criterion, the profiles deviated significantly from parallelism, $F(1,15)=13.14$, $p = .002$, partial $\eta^2 = .47$. Given that the profiles were not parallel, the tests for flatness and levels were meaningless and therefore are not reported. However, to investigate the source of the deviation from parallelism, simple-effects contrasts were conducted.
Figure 2. Profile plot for mean rates of directed and non-directed infant gestures in a clinic context.

Between-group contrasts of directed gestures and non-directed gestures. Two \textit{a priori} independent samples \textit{t} tests were conducted to evaluate the hypothesis that high-risk infants have a lower rate of directed gestures and a higher rate of non-directed gestures than low-risk infants in a clinic context. Both tests were significant and consistent with the research hypotheses. High-risk infants had a significantly lower rate of directed gestures ($M = 2.61, SD = 1.30$) than low-risk infants ($M = 4.22, SD = .93$), $t(15) = 2.98, p = .009, d = -1.45$. Moreover, high-risk infants had a significantly higher rate of non-directed gestures ($M = 2.40, SD = .97$) than low-risk infants ($M = 1.17, SD = .47$), $t(9.82) = 3.27, p = .009, d = 1.59$. Results of these analyses indicate that infants at risk for autism use a significantly lower rate of
directed gestures and a significantly higher rate of non-directed gestures than low-risk infants in a clinic context.

*Within-group contrasts of directed and non-directed gestures.* The profile analysis yielded a profile plot suggesting that high-risk infants had similar rates of directed and non-directed gestures, whereas low-risk infants had a higher rate of directed than non-directed gestures in a clinic context. Two post-hoc paired-samples t tests were therefore conducted to determine whether the mean rates of directed and non-directed gestures were significantly different within each group of infants. Experiment-wise, \( \alpha = .05 \) was achieved by setting \( \alpha \) for the test at .025 (.05 divided by two comparisons). The rates of directed and non-directed gesture use in high-risk infants were not significantly different \( t(7) = .290, p = .780 \), indicating that high-risk infants use directed and non-directed gestures at similar rates. However, when rates of directed and non-directed gestures were compared in low-risk infants, the result indicated a significant difference, \( t(8) = 7.68, p = .000, d = 2.51 \). Low-risk infants used directed gestures at a significantly higher rate than non-directed gestures in a clinic context.

*Home context.*

*Between-group comparison of profiles of directedness of gestures.* To investigate the hypothesis that high- and low-risk infants have different profiles of directed and non-directed gesture use in a home context, a profile analysis was conducted to examine directedness of gestures. The independent variable was group (i.e., high- and low-risk). The dependent variable was gesture directedness (i.e., mean rates of directed and non-directed gestures). Mean rates of directed and non-directed gestures were normally distributed for both groups in the home context and the assumption of homogeneity of variance was met. The covariance matrices for the dependent variables were equal across groups. The profiles of directed and non-directed gestures in a home context appear in Figure 3. Using the Wilks-Lambda criterion, the profiles deviated significantly from parallelism, \( F(1, 15) = 15.15, p = .001 \), partial \( \eta^2 = .50 \). Given that the profiles were not parallel, the tests for flatness and levels were meaningless and therefore are not reported.
However, to investigate the source of the deviation from parallelism, simple effects analyses were conducted.

**Directed and Non-Directed Gestures Home**

![Graph showing mean rate of directed and non-directed gestures by diagnostic group.]

**Figure 3.** Profile plot for mean rates of directed and non-directed infant gestures in a home context.

*Between-group contrasts of directed and non-directed gestures.* Two *a priori* independent samples *t* tests were conducted to evaluate the hypothesis that high-risk infants have a lower rate of directed gestures and a higher rate of non-directed gestures than low-risk infants in a home context. Both tests were significant and consistent with the research hypotheses. High-risk infants had a significantly lower rate of directed gestures (*M* = 2.10, *SD* = .89) than low-risk infants (*M* = 3.73, *SD* = .85), *t*(15) = 3.85, *p* = .002, *d* = -1.87. Moreover, high-risk infants had a significantly higher rate of non-directed gestures (*M* = 2.27, *SD* = .84) than low-risk infants (*M* = 1.22, *SD* = .72), *t*(15) = 2.77, *p* = .014, *d* = 1.35. Results of these analyses indicate that
infants at risk for autism used a significantly lower rate of directed gestures and a significantly higher rate of non-directed gestures than low-risk infants in a home context.

Within-group contrasts of directed and non-directed gestures. The profile analysis yielded a profile plot, which suggested that high-risk infants had similar rates of directed and non-directed gestures whereas low-risk infants had a higher rate of directed than non-directed gestures in a home context. Two post-hoc paired-samples t tests were therefore conducted to determine whether the mean rates of directed and non-directed gestures were significantly different within each group of infants. Experiment-wise α = .05 was achieved by setting α for the test at .025 (.05 divided two comparisons). The mean rates of directed and non-directed gesture use in high-risk infants were not significantly different t(7) = .287, p = .782, indicating that high-risk infants use directed and non-directed gestures at similar rates. However, when rates of directed and non-directed gestures were compared in low-risk infants the result indicated a significant difference, t(8) = 6.372, p = .000, d = 2.12. Low-risk infants use directed gestures at a significantly higher rate than non-directed gestures in a home context.

An examination of the two profile plots for directed and non-directed gestures in clinic and at home revealed the possibility that even if directed and non-directed gestures were examined together, high-risk infants would have a combined gesture rate that was lower than the combined gesture rate for low-risk infants. A post-hoc question was developed to examine this hypothesis.

Raw counts of directed gestures and non-directed gestures were summed and divided by time (per minute) for each infant in both groups to create a combined directed and non-directed gesture rate for clinic and home contexts. Mean rates of combined gestures were calculated for each group and each context (i.e., clinic and home). Combined gesture rates were normally distributed with equal variances for both groups in both contexts. To compare the combined gesture rates of the groups, two independent samples t tests were conducted. In the clinic context, there was no significant difference in the combined rate of gestures for high-
5.00, \(SD = 1.14\) and low-risk infants \((M = 5.40, SD = .85)\), \(t(15) = .81, p = .431\).
Similarly, in the home context there was no significant difference in the combined rate of gestures for high- \((M = 4.37, SD = .56)\) and low-risk infants \((M = 4.95, SD = 1.03)\), \(t(15) = 1.41, p = .18\).

**Individual case profiles.** An examination of individual cases was conducted to determine the proportions of total gestures that were non-directed for each infant. The proportion (expressed in percentage) of non-directed gestures was calculated for each case by dividing the raw number of non-directed gestures produced by the raw number of total gestures (directed plus non-directed) produced. The mean percentage of non-directed gestures across clinic and home contexts was then calculated. Mean proportions of non-directed gestures and diagnostic outcome status at 24 months of age for high-risk infants are reported in Table 12. Of the seven high-risk infants meeting criteria for an ASD at 24 months, four infants (cases 1, 2, 3, and 4) produced non-directed gestures as the majority of their gestures (> 50%) and three infants (cases 5, 6, and 7) used non-directed gestures at a proportion of more than 40% of their total gestures. The one high-risk infant later diagnosed with language delay (case 8) had the lowest proportion of non-directed gestures in the high-risk group.

Diagnostic outcome status at 24 months of age was available for eight of the nine infants in the low-risk group. None of these eight infants met criteria for ASD. With respect to individual case profiles in the low-risk group, no cases had more than 40% of gestures that were non-directed. The case with the highest proportion of non-directed gestures (case 9) had a total score of 6 on the ADOS (summed scores for *Communication* and *Social Interaction*) at 18 months of age. A score of 6 is one point below the cut-off for ASD. Diagnostic status at 24 months of age for this case could not be determined as this case withdrew from the longitudinal study. All other low-risk infants received an ADOS score well below cut-off for ASD.
Table 12

Mean Proportion (as percentage) of Non-directed Gestures for Individual Cases

Averaged Across Clinic and Home Contexts

<table>
<thead>
<tr>
<th>Low-Risk Infants</th>
<th>% Non-directed Gestures</th>
<th>High-Risk Infants</th>
<th>% Non-directed Gestures</th>
<th>Diagnostic Category¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>11.9</td>
<td>Case 1</td>
<td>70.0</td>
<td>Autism</td>
</tr>
<tr>
<td>Case 2</td>
<td>13.6</td>
<td>Case 2</td>
<td>69.5</td>
<td>Autism</td>
</tr>
<tr>
<td>Case 3</td>
<td>15.6</td>
<td>Case 3</td>
<td>64.4</td>
<td>ASD</td>
</tr>
<tr>
<td>Case 4</td>
<td>16.1</td>
<td>Case 4</td>
<td>56.0</td>
<td>Autism</td>
</tr>
<tr>
<td>Case 5</td>
<td>25.2</td>
<td>Case 5</td>
<td>45.7</td>
<td>ASD</td>
</tr>
<tr>
<td>Case 6</td>
<td>26.6</td>
<td>Case 6</td>
<td>41.9</td>
<td>ASD</td>
</tr>
<tr>
<td>Case 7</td>
<td>28.4</td>
<td>Case 7</td>
<td>40.7</td>
<td>ASD</td>
</tr>
<tr>
<td>Case 8</td>
<td>31.2</td>
<td>Case 8</td>
<td>19.1</td>
<td>Language delay</td>
</tr>
<tr>
<td>Case 9</td>
<td>39.7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ Diagnostic category is based on ADOS (Lord et al., 1999) summed scores for Communication and Social Interaction algorithm domains (scores above cut-off for autism or ASD).

In summary, the two groups of infants had profiles of directed and non-directed gesture use that were significantly different. High-risk infants used directed and non-directed gestures at similar rates whereas low-risk infants used directed gestures at a significantly higher rate than non-directed gestures. When the two groups were compared, high-risk infants were found to direct their gestures at a significantly lower rate than low-risk infants and had a significantly higher rate of non-directed gestures. These findings were consistent in clinic and home contexts. A post-hoc analysis showed that when directed and non-directed gesture rates were combined, high- and low-risk infants gestured at similar rates but approximately half of the gestures produced by high-risk infants were not directed to a communicative partner. This finding was also consistent across clinic and home contexts. With respect to individual case profiles of directedness, all high-risk
infants later diagnosed with ASD had a proportion of non-directed gestures of more than 40% of their total gestures, four of whom produced non-directed gestures as the majority of their total gestures with proportions ranging from 56% to 70%. None of the low-risk infants had proportions of non-directed gestures greater than 40%.

**Types of gestures.** The second question of this study asked whether high- and low-risk infants had the same profile for three types of gestures: deictic, conventional, and representational. All analyses examining the profiles for gesture types hereafter include only directed gestures in order to be able to interpret the results in the context of the current literature on infant gesture use. The mean rates and standard deviations for each type of gesture in clinic and home contexts are displayed in Table 13.

An examination of the distributions by group revealed that the data were not normally distributed for four dependent variables: representational gestures for high-risk infants (clinic context), deictic gestures for high-risk infants (home context), and representational gestures for both groups (home context). Representational gestures are the latest to emerge developmentally (Acredolo & Goodwyn, 1988; Capirci, Iverson, Pizutto, & Volterra, 1996; Caselli, 1990; Crais et al., 2004), it was therefore expected that, given the age of the participants, there would be some infants in both groups who would not produce any representational gestures. Three low-risk infants and six high-risk infants produced no representational gestures in the clinic context. In the home context, two low-risk and four high-risk infants produced no representational gestures. The procedures to deal with violations of the normality assumption are described below for each dependent variable by context.
Table 13
Means Rates and Standard Deviations for Gesture Types in Clinic and Home Contexts by Group

<table>
<thead>
<tr>
<th>Gesture Types</th>
<th>High-Risk Infants (n = 8)</th>
<th>Low-Risk Infants (n = 9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deictic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinic</td>
<td>M (SD) 1.36 (1.04)</td>
<td>2.94 (1.02)</td>
</tr>
<tr>
<td></td>
<td>Min–Max .47–3.31</td>
<td>1.55–4.98</td>
</tr>
<tr>
<td>Home</td>
<td>M (SD) 1.04 (.82)</td>
<td>2.22 (.62)</td>
</tr>
<tr>
<td></td>
<td>Min–Max .52–2.95</td>
<td>1.46–3.48</td>
</tr>
<tr>
<td>Conventional</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinic</td>
<td>M (SD) 1.19 (.75)</td>
<td>1.20 (.64)</td>
</tr>
<tr>
<td></td>
<td>Min–Max .23–2.30</td>
<td>.34–2.38</td>
</tr>
<tr>
<td>Home</td>
<td>M (SD) .94 (.33)</td>
<td>1.28 (.63)</td>
</tr>
<tr>
<td></td>
<td>Min–Max .56–1.55</td>
<td>.42–2.26</td>
</tr>
<tr>
<td>Representational</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinic</td>
<td>M (SD) .06 (.11)</td>
<td>.09 (.09)</td>
</tr>
<tr>
<td></td>
<td>Min–Max .00–.26</td>
<td>.00–.26</td>
</tr>
<tr>
<td>Home</td>
<td>M (SD) .12 (.20)</td>
<td>.22 (.25)</td>
</tr>
<tr>
<td></td>
<td>Min–Max .00–.54</td>
<td>.00–.67</td>
</tr>
</tbody>
</table>

Clinic context.

Between-group comparison of profiles of gesture type. To investigate the hypothesis that high- and low-risk infants have different profiles of gesture type in a clinic context, a profile analysis was conducted to examine the three types of gestures used. The independent variable was group (i.e., high- and low-risk). The dependent variable was gesture type (i.e., mean rates of deictic, conventional, and representational gestures).

The data for deictic and conventional gesture rates were normally distributed for each group. However, as noted above, the data for representational
gestures violated the assumption of normality $W(8), = .59, p = .000$. Because representational gestures emerge later developmentally than deictic or conventional gestures (Acredolo & Goodwyn, 1988; Capirci et al., 1996; Caselli, 1990; Crais et al., 2004), the non-normal distribution of this sample was likely consistent with a non-normal distribution of representational gestures in a population of 15-month-old infants, therefore it was deemed prudent to include these data in the analyses. However, MANOVA is sensitive to both outliers and significantly skewed data (Tabachnick & Fidell, 2007), therefore, the distribution of these data was re-examined. It was not possible to detect outliers given the limited number of infants who produced representational gestures in both groups. Although MANOVA is relatively robust to modest violations of normality, marked, significant skewness can influence analyses (Tabachnick & Fidell, 2007). Therefore the skewness of the distribution of representational gesture in the high-risk group was calculated using $z$ scores (skewness value divided by the standard error for skewness). This alternate method of evaluating normality yielded a $z$ score, indicating that these data were not significantly skewed ($z = 1.99$, where scores $\geq 3.3$ indicate significant skewness). So although the data were limited, the investigator decided to include the data for representational gestures in the profile analyses in order to present rates of these gestures relative to the other types of gestures. However, representational gestures were excluded from simple-effects contrasts because of the limited data.

The test for homogeneity of variance was not significant. The covariance matrices for the dependent variables were equal across groups. However, the test for sphericity was violated, therefore the Greenhouse-Geisser adjustment was used. The profiles of types of gestures seen in Figure 4 deviated significantly from parallelism, $F(1.30, 19.51)= 6.11, p = .017$, partial $\eta^2 = .29$. Given that the profiles were not parallel, the tests for flatness and levels were meaningless and therefore are not reported. However, to investigate the source of the deviation from parallelism, simple-effects contrasts were conducted.
Figure 4. Profile Plot for Mean Rates of Infant Gesture Types in a Clinic Context.

Within-group contrasts of gesture types. Guided by the hypothesis that low-risk infants would have a higher rate of deictic than conventional gestures, whereas high-risk infants would have a higher rate of conventional than deictic gestures, an a priori paired-samples t test was conducted for each within-group comparison.

Contrary to the hypothesis, there was no significant difference between the rate of conventional gestures \((M = 1.36, SD = 1.04)\) and deictic gestures \((M = 1.19, SD = .75)\), \(t(7) = .37, p = .723\), in high-risk infants. Consistent with the hypothesis, results indicated that in low-risk infants the mean rate of deictic gestures \((M = 2.94, SD = 1.02)\) was significantly higher than the mean rate of conventional gestures \((M = 1.20, SD = .64)\), \(t(8) = 3.66, p = .006, d = 1.22\).

Between-group contrasts of gesture types. The profile analysis yielded a profile plot in which it appeared that high-risk infants had a lower mean rate of deictic gestures than low-risk infants. To examine whether this group difference
was significant, a post-hoc analysis was conducted. Significance level $\alpha = .05$ was achieved by setting $\alpha$ for the test at $.017$ ($.05$ divided by three comparisons) because although only one contrast was performed, three contrasts were considered following an inspection of the profile plot (i.e., between group comparisons for deictic, conventional, and representational gestures). An independent-samples $t$ test revealed that high-risk infants had a significantly lower rate of deictic gestures than low-risk infants, $t(15) = 3.16, p = .006, d = 1.53$.

**Home context.**

*Between-group comparison of profiles of gesture types.* To investigate the hypothesis that high- and low-risk infants have different profiles of gesture types in a home (i.e., naturalistic) context, a profile analysis was conducted to examine the profile of three gesture types used. The independent variable was group (i.e., high- and low-risk). The dependent variable was gesture type (i.e., mean rates of deictic, conventional, and representational gestures). The data for conventional gesture rate were normally distributed. However, the data for deictic gestures for the high-risk group violated the assumption of normality, $W(8) = .68, p = .001$. Also, the data for representational gestures for both groups were not normally distributed (high-risk infants, $W(8) = .71, p = .003$; low-risk infants, $W(9) = .82, p = .038$). As noted above, MANOVA is sensitive to outliers and significantly skewed data (Tabachnick & Fidell, 2007), therefore, the distribution of these data was re-examined.

A visual inspection of the histogram revealed one case with a high rate of deictic gestures that appeared to be disconnected from the distribution for the high-risk group. Given that profile analysis is sensitive to outliers (Tabachnick & Fidell, 2007), procedures recommended by Van Selst and Jolicoeur (1994) for identifying and eliminating outliers for small sample sizes were followed resulting in one case being identified and removed for all three dependent variables. The removal of the

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1The mean rate of deictic gestures and standard deviations for the high-risk group was computed ($M = 1.05, SD = .82$). The case with the highest rate of deictic gestures ($2.95/\text{min}$) was temporarily removed and the mean and standard deviation for the remaining 7 cases was computed ($M = .77, SD = .30$). The removed case was then re-included in the sample. The highest and lowest rate of deictic gestures were examined to determine whether these fell outside the recommended cut-of values for a sample size of 8 using the modified recursive procedure, which was $+/-4.475$ standard deviations from the group mean. Therefore, cases with rates outside the range of $-0.59$ (a meaningless value) and $2.13$, were identified as an outlier. The lowest rate in the sample was $.52/\text{min}$ and the highest rate in the sample was $2.95/\text{min}$. The case with a rate of $2.95$ deictic gestures was identified as a statistical outlier and removed.
outlier improved the distribution but did not result in normal distribution of the rate of deictic gestures for the remaining sample \( W(7), = .70, p = .029 \).

Three options were then explored. Because significantly skewed data can also influence MANOVA (Tabachnick & Fidell, 2007), a skewness test was conducted on the remaining sample for all three variables by dividing skewness by the standard error for skewness. Values greater than 3.3 indicate significant skewness. The skewness test results were 2.36, 1.18, and 1.94 for deictic, conventional, and representational gestures, respectively. None of these values was greater than or equal to 3.3, indicating that none of the variables were significantly skewed. The first option was thus to proceed with the profile analysis with the outlier removed in spite of the distribution. Although not normally distributed, the data were not significantly skewed. A profile analysis was conducted to compare the three types of gesture profiles in high- and low-risk infants. The Greenhouse-Geisser adjustment showed the profiles deviated significantly from parallelism, \( F(1.41, 19.76) = 9.62, p = .003, \) partial \( \eta^2 = .41 \), indicating that high-risk infants do not have the same profile of gesture types as low-risk infants.

A second option was to attempt to normalize the data for deictic gestures in the high-risk group by applying a transformation to all three variables. Using the sample of seven (i.e., with the outlier excluded), the data were transformed using a square root transformation, which is recommended for moderate violations of normality (Tabachnick & Fidell, 2007). The transformation was successful in normalizing the distribution for both deictic and conventional gestures (but not representational gestures). As described above, although the data for representational gestures were not normally distributed, it was decided to include the data in the profile analyses in order to present rates of these gestures relative to the other types of gestures. However, representational gestures were excluded from simple effects contrasts because of the limited data. The profile analysis proceeded using the transformed data. Using the Wilks-Lambda criterion the profiles deviated significantly from parallelism \( F(2, 13) = 4.10, p = .042, \) partial \( \eta^2 = .39 \).
A third option was to analyze the entire sample (i.e., not exclude the outlier). Three reasons are presented to support this option. First, although the infant with the highest rate of deictic gestures was a statistical outlier, this infant may not be an outlier in the population of 15-month-old infants at risk for autism. Some high-risk infants do not go on to meet criteria for an ASD diagnosis and, although they may have relatively intact language abilities, differences in early gesture development persist (Mitchell et al., 2006). So although this infant’s high rate of deictic gestures suggests that the case is an outlier in the sample, it is unlikely that it is an outlier in the population. It would thus be important to include this infant in the sample. Second, the case determined to be a statistical outlier had the highest rate of deictic gesture use in the sample of high-risk infants. Including this infant in the sample raised the overall group mean and, therefore, may result in a more conservative analysis. Third, the results from the profile analyses remained significant even when more stringent options were considered (i.e. with the outlier excluded or using transformed data). It was therefore decided to include the statistical outlier in the sample of high-risk infants and proceed with a profile analysis. Covariance matrices of the dependent variables were equal across groups. However, the test for sphericity was violated so the Greenhouse-Geisser adjustment was therefore used. The profiles of types of gestures displayed in Figure 5 deviated significantly from parallelism, $F(1.38, 20.75) = 4.64, p = .033$, partial $\eta^2 = .24$. Given that the profiles are not parallel, the tests for flatness and levels are meaningless and are thus not reported. However, the source of the deviation from parallelism was investigated by performing simple effects analyses.
Within-group contrasts of gesture types. Hypotheses regarding the profile of types of gestures for the home context were the same as for the clinic context (i.e., that low-risk infants would have a higher rate of deictic than conventional gestures, whereas high-risk infants would have a higher rate of conventional than deictic gestures). An *a priori* comparison was conducted for each within-group comparison. It was necessary to use non-parametric tests because of the non-normal distribution of deictic gestures in the high-risk group. Two Wilcoxon Signed Ranks tests were conducted to evaluate whether high-risk infants would have a higher rate of conventional than deictic gestures and whether low-risk infants would have a higher rate of deictic than conventional gestures. Contrary to the hypothesis, high-risk infants did not have a significantly higher mean rate of conventional gestures ($M = .94, SD = .33$) than deictic gestures ($M = 1.05, SD = .82$). Results revealed no
significant difference between the use rates of these two gesture types, $z = -1.7, p = .866$. Consistent with the hypothesis, the results indicated that in low-risk infants, the mean rate of deictic gestures ($M = 2.22, SD = .62$) was significantly higher than the mean rate of conventional gestures ($M = 1.30, SD = .63$), $z = -2.07, p = .038, r = 0.69$.

*Between-group contrasts of gesture types.* The profile analysis yielded a profile plot that suggested high-risk infants had lower mean rates of deictic and conventional gestures than low-risk infants. To examine whether these group differences were significant, two post-hoc analyses were conducted. Level of significance $\alpha = .05$ was achieved by setting $\alpha$ for each test at .017 (.05 divided by 3 comparisons) because, although only two contrasts were performed, three contrasts were considered following an inspection of the profile plot (i.e., between group comparisons for deictic, conventional, and representational gestures). Again, a non-parametric test to compare rates of deictic gestures was conducted because of the non-normal distribution of this variable in the high-risk group. A Mann-Whitney $U$ test was conducted and revealed that high-risk infants had a significantly lower rate of deictic gestures than low-risk infants, $z = -2.69, p = .007, r = -.65$. A Mann-Whitney $U$ test was conducted to compare groups with respect to rates of conventional gesture use. There was no significant group difference in the rate of conventional gesture use $z = -1.06, p = .290$.

In summary, high-risk infants had a significantly different profile of gesture types than did low-risk infants in both contexts. High-risk infants used deictic and conventional gestures at similar rates whereas low-risk infants used deictic gestures at a significantly higher rate than conventional gestures in both contexts. Furthermore, as a group, high-risk infants used deictic gestures at significantly lower rates than low-risk infants in both contexts.

*Communicative functions of gestures.* All analyses examining the profile for functions of gestures included only directed gestures so that interpretation of the results can be within the context of the current literature on infant gesture use.
The mean rates and standard deviations for each communicative function in the clinic and home contexts are displayed in Table 14.

Table 14
*Means and Standard Deviations for Gesture Functions in Clinic and Home Contexts by Group*

<table>
<thead>
<tr>
<th>Gesture Functions</th>
<th>High-Risk Infants (n = 8)</th>
<th>Low-Risk Infants (n = 9)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Behaviour Regulation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinic</td>
<td>M (SD) 1.58 (.92)</td>
<td>1.77 (.46)</td>
</tr>
<tr>
<td></td>
<td>Min–Max .62–3.05</td>
<td>1.05–2.47</td>
</tr>
<tr>
<td>Home</td>
<td>M (SD) 1.13 (.70)</td>
<td>1.51 (.49)</td>
</tr>
<tr>
<td></td>
<td>Min–Max .47–2.01</td>
<td>.93–2.23</td>
</tr>
<tr>
<td><strong>Social Interaction</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinic</td>
<td>M (SD) .41 (.30)</td>
<td>.45 (.27)</td>
</tr>
<tr>
<td></td>
<td>Min–Max .03–.83</td>
<td>.12–.87</td>
</tr>
<tr>
<td>Home</td>
<td>M (SD) .49 (.38)</td>
<td>.69 (.46)</td>
</tr>
<tr>
<td></td>
<td>Min–Max .07–1.09</td>
<td>.08–1.46</td>
</tr>
<tr>
<td><strong>Joint Attention</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinic</td>
<td>M (SD) .62 (.45)</td>
<td>2.00 (1.02)</td>
</tr>
<tr>
<td></td>
<td>Min–Max .05–1.28</td>
<td>.56–3.34</td>
</tr>
<tr>
<td>Home</td>
<td>M (SD) .48 (.55)</td>
<td>1.49 (.55)</td>
</tr>
<tr>
<td></td>
<td>Min–Max .00–1.58</td>
<td>.98–2.50</td>
</tr>
</tbody>
</table>

**Clinic context.**

*Between-group comparison of profiles of gesture functions.* To investigate the hypothesis that high- and low-risk infants have different gesture profiles for communicative functions in a clinic context, a profile analysis was conducted to examine gestures used for three communicative functions. The independent variable was group (high- and low-risk). The dependent variable was...
communicative function of the gesture (i.e., mean rates of gestures used for behaviour regulation, social interaction, and joint attention).

The data for the three communicative functions were normally distributed for each group but the test for homogeneity of variance was violated for behaviour regulation and joint attention. The covariance matrices for the dependent variables were equal across groups. The profiles of the three communicative functions in a clinic context appear in Figure 6. Using the Wilks-Lambda criterion the profiles deviated significantly from parallelism, $F(2, 14)= 4.22, p = .037$, partial $\eta^2 = .38$. Given that the profiles were not parallel, the tests for flatness and levels were meaningless and therefore are not reported. However, to investigate the source of the deviation from parallelism, simple effects analyses were conducted.

**Communicative Function of Gestures Clinic**

![Diagram showing the communicative function of gestures in a clinic context.](image)
Figure 6. Profile Plot for Mean Rates of Communicative Functions of Infant Gestures in a Clinic Context.

Within-group contrasts of gesture functions. To investigate the hypothesis that high-risk infants would use gestures at a higher rate for behaviour regulation than for social interaction or joint attention and that low-risk infants would use gestures for joint attention at a higher rate than for behaviour regulation or social interaction, three a priori paired-samples $t$ tests were conducted for each within group comparison. Level of significance $\alpha = .05$ was achieved by setting $\alpha$ for each test at $0.017$ ($0.05$ divided by 3 comparisons). Results indicated that high-risk infants used gestures significantly more often for behaviour regulation ($M = 1.58, SD = .92$) than for social interaction ($M = .41, SD = .30$), $t(7) = 3.68, p = .008, d = 1.30$, and joint attention ($M = .62, SD = .44$), $t(7) = 3.39, p = .012, d = 1.20$. There were no significant differences between gesture rates for joint attention and social interaction $t(7) = 1.22, p = .262$. Low-risk infants also used gestures for behaviour regulation significantly more often than for social interaction $t(8) = 6.43, p = .000, d = 2.14$. However, unlike the high-risk group, low-risk infants used gestures more often for joint attention than for social interaction, ($M = .45, SD = .27$), $t(8) = 3.88, p = .005, d = -1.29$. Unlike the high-risk group, gestures used for joint attention ($M = 2.00, SD = 1.02$) and behaviour regulation ($M = 1.77, SD = .46$), were not significantly different in low-risk infants $t(8) = .60, p = .567$.

Between-group contrasts of gesture functions. The profile analysis yielded a profile plot suggesting that high-risk infants had a lower rate of gestures for joint attention than low-risk infants. To examine whether this group difference was significant, a post-hoc analysis was conducted. Level of significance $\alpha = .05$ was achieved by setting $\alpha$ for the test at $0.017$ ($0.05$ divided 3 comparisons) because, although only one contrast was performed, three contrasts were considered following an inspection of the profile plot (i.e., between group comparisons for deictic, conventional, and representational gestures). An independent-samples $t$ test revealed that high-risk infants used gestures at a significantly lower rate for joint attention than low-risk infants, $t(11.21) = 3.69, p = .003, d = 1.79$. 

82
**Home context.**

*Between-group comparison of profiles of gesture functions.* To investigate the hypothesis that high- and low-risk infants have different gesture profiles for communicative functions in a naturalistic home context, a profile analysis was conducted to examine gestures used for three communicative functions. The independent variable was group (high- and low-risk). The dependent variable was communicative function (i.e., mean rates of gestures used for behaviour regulation, social interaction, and joint attention). The data for the behaviour regulation function violated the assumption of normality in the high-risk group, \( W(8) = .77, p = .013 \). Social interaction and joint attention gestures were normally distributed in the high-risk group, as were the data for all three communicative functions for the low-risk group.

To determine the source of the non-normal distribution of the data for behaviour regulation in the high-risk group, the distribution of this variable was examined. Given that profile analysis is sensitive to outliers (Tabachnick & Fidell, 2007), procedures recommended by Van Selst and Jolicouer (1994) for identifying and eliminating outliers for small sample sizes were followed.\(^1\) No cases were identified as outliers. The presence of an outlier was not the source of the non-normal distribution. Because significantly skewed data can also influence MANOVA (Tabachnick & Fidell, 2007), the investigator conducted a skewness test on the complete sample of high-risk infants for behaviour regulation gestures by dividing the skewness by the standard error for skewness. A value greater than 3.3 indicates significant skewness. The skewness test result was .73 indicating that these data were not significantly skewed. Therefore, the investigator decided to proceed with the profile analysis.

The covariance matrices for the dependent variables were equal across groups. The profiles of the three communicative functions appear in Figure 7. Using\(^1\)

---

\(^1\)The mean rate of gestures for behaviour regulation and standard deviations for the high-risk group were computed \((M = 1.13, SD = .70)\). The case with the highest rate of gestures for behaviour regulation (2.01/min) was temporarily removed and the mean and standard deviation for the remaining seven cases was computed \((M = 1.00, SD = .65)\). The removed case was then re-included in the sample. The highest and lowest rate of deictic gestures were examined to determine whether they fell outside the recommended cut-off values for a sample size of eight using the modified recursive procedure, which was +/- 4.475 standard deviations from the group mean. Therefore, cases with rates outside the range of -2.00 (a meaningless value) and 3.91 would be statistical outliers.
the Wilks-Lambda criterion the profiles deviated significantly from parallelism, \( F(2, 14) = 5.10, p = .022 \), partial \( \eta^2 = .42 \). Given that the profiles were not parallel, the tests for flatness and levels were meaningless and therefore are not reported. However, to investigate the source of the deviation from parallelism, simple effects analyses were conducted.

![Figure 7](image)

**Figure 7.** Profile Plot for Mean Rates of Communicative Functions of Infant Gestures in a Home Context.

**Within-group contrasts of gesture functions.** To test the hypothesis that high-risk infants would use gestures at a higher rate for behaviour regulation than for social interaction or joint attention, whereas low-risk infants would use gestures for joint attention at a higher rate than for behaviour regulation or social interaction, three *a priori* contrasts were conducted for each within-group comparison. Level of
significance $\alpha = .05$ was achieved by setting $\alpha$ for each test at .017 (.05 divided by 3 comparisons). A non-parametric, Wilcoxon Signed Ranks tests was conducted to examine the three gesture functions in the high-risk group because of the non-normal distribution of the behaviour regulation variable. Contrary to the hypotheses, in the high-risk group, there were no significant differences in the rates of gestures used for behaviour regulation ($M = 1.13, SD = .70$) and social interaction ($M = .49, SD = .38$), $z = -1.35, p = .176$, social interaction and joint attention ($M = .48, SD = .55$), $z = -.11, p = .917$ or behaviour regulation and joint attention, $z = -1.96, p = .050$. Contrary to the hypothesis, low-risk infants used gestures for joint attention ($M = 2.00, SD = 1.02$) and behaviour regulation ($M = 1.77, SD = .46$) at similar rates, $z = -.06, p = .953$. In addition, low-risk infants used gestures for behaviour regulation and social interaction ($M = .45, SD = .27$) at similar rates, $z = -2.19, p = .028$.

Consistent with the hypothesis, low-risk infants used gestures significantly more often for joint attention than for social interaction, $z = -2.67, p = .008, r = -.89$.

**Between-group contrasts of gesture functions.** The profile analysis yielded a profile plot suggesting that high-risk infants had a lower rate of gestures used for joint attention than low-risk infants. To examine whether this group difference was significant, a post-hoc analysis was conducted. Level of significance $\alpha = .05$ was achieved by setting $\alpha$ for the test at .017 (.05 divided by 3 comparisons) because although only one contrast was performed, three contrasts were considered following an inspection of the profile plot (i.e., between group comparisons for behaviour regulation, social interaction, and joint attention gestures. An independent-samples $t$ test revealed that high-risk infants used gestures at a significantly lower rate for joint attention than low-risk infants, $t(15) = 3.80, p = .002, d = 1.85$.

In summary, compared to low-risk infants, high-risk infants had significantly different profiles of communicative functions in both contexts. In the clinic context, high-risk infants used gestures for behaviour regulation at a significantly higher rate than for joint attention whereas in the home context gestures for these functions did not differ significantly. High-risk infants also gestured for behaviour regulation
significantly more often than for social interaction in both contexts. Rates of gestures for joint attention and social interaction were similar in both contexts. On the other hand, low-risk infants used gestures for behaviour regulation and joint attention at similar rates in both contexts. In the clinic context, low-risk infants gestured more often for behaviour regulation than social interaction although gestures for these communicative functions were not different in the home context. Low-risk infants used gestures for joint attention more often than for social interaction in both contexts. Although within-group profiles differed somewhat in clinic versus home contexts, the between-group comparisons of gesture functions indicated that, as a group, high-risk infants gestured for joint attention at a significantly lower rate than low-risk infants in both contexts.

**Symbolic play acts.** Symbolic play acts were examined in clinic and home contexts. Mean rates and standard deviations for symbolic play acts are presented in Table 15.

Table 15

*Means and Standard Deviations for Infant Symbolic Play Acts in Clinic and Home Contexts by Group*

<table>
<thead>
<tr>
<th>Symbolic Play Acts</th>
<th>High-Risk Infants (n = 8)</th>
<th>Low-Risk Infants (n = 9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinic</td>
<td>M (SD)</td>
<td>1.16 (.46)</td>
</tr>
<tr>
<td></td>
<td>.63 (.71)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Min−Max</td>
<td>0.00−1.97</td>
</tr>
<tr>
<td></td>
<td>0.56−1.76</td>
<td></td>
</tr>
<tr>
<td>Home</td>
<td>M (SD)</td>
<td>1.79 (.40)</td>
</tr>
<tr>
<td></td>
<td>.80 (.71)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Min−Max</td>
<td>1.07−2.38</td>
</tr>
</tbody>
</table>

**Clinic context.** An independent-samples t test was conducted to evaluate the hypothesis that high-risk infants had a lower rate of symbolic play acts than low-risk infants in a clinic context. The rates of symbolic play acts were normally distributed in each group and the assumption of homogeneity of variance was met. Although high-risk infants appeared to have a lower rate of symbolic play acts (M = .63, SD = .71) than low-risk infants (M = 1.16, SD = .46) this difference was not
significant. Thus, contrary to the hypothesis, in a clinic context, groups did not differ significantly with respect to their rate of symbolic play, \( t(15) = 1.85, p = .084 \) (see Figure 8).

**Infants Symbolic Play Acts: Clinic**

![Bar chart showing mean rates of symbolic play acts in a clinic context for low-risk and high-risk infants.](chart.png)

*Figure 8*. Mean Rates and Standard Deviations of Infant Symbolic Play Acts in a Clinic Context.

**Home context.** An independent samples \( t \) test was conducted to evaluate the same hypothesis (i.e., that high-risk infants have a lower rate of symbolic play acts than low-risk infants) in a home context. The rates of symbolic play acts were normally distributed in each group and the assumption of homogeneity of variance was met. The test was significant, \( t(15) = 3.61, p = .003, d = 1.76 \). Consistent with the hypothesis, high-risk infants had a lower rate of symbolic play acts (\( M = .80, SD = \)
.71) than low-risk infants ($M = 1.79, SD = .40$) in a naturalistic, home context with their mothers (see Figure 9).

**Figure 9.** Mean Rates and Standard Deviations of Infant Symbolic Play Acts in a Home Context.

In summary, findings with respect to infants’ symbolic play acts differed in each context. In the clinic, groups did not differ significantly in their rates of symbolic play; in the home context, high-risk infants performed significantly fewer symbolic play acts than did low-risk infants.

**Parent-reported gestures.** As previously stated, early gestures refer to those that are primarily communicative (e.g., pointing to request, raising arms to ask to be picked up); late gestures refer to those that are primarily recognitory (i.e., that demonstrate the infant’s knowledge of appropriate actions with toys) or symbolic play gestures. Means and standard deviations for the total number of gestures for
each variable appear in Figure 10. Data for each dependent variable were normally distributed for each group and homogeneity of variance assumption was met.

![Parent-Reported Gestures](image)

*Figure 10. Mean Number and Standard Deviations of Parent-Reported Early and Late Gestures*

To investigate the hypotheses that high-risk infants would have fewer early and late gestures by parent report than low-risk infants, two *a priori* independent samples *t* tests were conducted. Results of both tests were significant, indicating that high-risk infants had significantly fewer early gestures \((M = 9.00, SD = 4.10)\) than low-risk infants \((M = 13.67, SD = 2.92)\), \(t(14) = 2.67, p = .018, d = 1.28\), and fewer late gestures \((M = 12.14, SD = 6.18)\) than low-risk infants \((M = 26.44, SD = 5.94)\), \(t(14) = 4.70, p = .000, d = 2.28\).

**Mothers**

The second series of research questions in this study examined: (a) the rate of maternal gesture use, (b) the profile of types of gestures, (c) the profile of communicative functions of gestures, (d) symbolic play acts, (e) the profile of the relationship between gestures and accompanying language, and (f) the profile of maternal prompts to encourage gesture use. To clarify, all analyses of maternal gestures were of directed gestures as non-directed gestures were not examined. Profile Analysis was selected as the most appropriate statistical model to address
questions regarding the profile of types and functions of gestures as well as the relationship between gesture and language (emphasize, disambiguate, add). Symbolic play acts were examined using a non-parametric test for independent samples. For all analyses an alpha level of .05 was employed.

**Rate of gesture use.** To investigate the hypothesis that mothers of high-risk infants would gesture less than mothers of low-risk infants, the two groups of mothers were compared with respect to overall gesture rate. The independent variable was the diagnostic group of the infant (i.e., mothers of high- and low-risk infants). The dependent variable was gesture type (i.e., mean rates of maternal gestures). Mean overall maternal gesture rates and standard deviations are presented in Table 16. An independent-samples $t$ test was conducted to explore the overall rate of maternal gesture use in a naturalistic play context with their infants. The overall rates of maternal gesture use were normally distributed in each group and the groups did not differ significantly in variance. The test was not significant, $t(15) = .65, p = .529, d = .31$. There was no significant difference in the rate of maternal gesture use between mothers of high-risk infants ($M = 6.86, SD = 1.37$) and mothers of low-risk infants ($M = 6.46, SD = 1.23$) in a naturalistic, home context.

<table>
<thead>
<tr>
<th>Gesture</th>
<th>Mothers of High-Risk</th>
<th>Mothers of Low-Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>Min–Max</td>
</tr>
<tr>
<td>Overall Rate</td>
<td>6.86 (1.37)</td>
<td>5.37–9.40</td>
</tr>
<tr>
<td>Deictic</td>
<td>3.68 (1.15)</td>
<td>2.96–6.42</td>
</tr>
<tr>
<td>Conventional</td>
<td>2.29 (1.16)</td>
<td>1.17–4.27</td>
</tr>
<tr>
<td>Representational</td>
<td>.89 (.54)</td>
<td>.30–1.93</td>
</tr>
</tbody>
</table>

### Types of gestures.

*Between-group comparison of profiles of gesture types.* To investigate the hypothesis that mothers of high- and low-risk infants have different profiles of
gesture types a profile analysis was conducted to examine the three types of maternal gestures. The independent variable was group. The dependent variable was gesture type (i.e., mean rates of deictic, conventional, and representational gestures). The means and standard deviations for the three types of gestures are displayed in Table 16. The data for all variables for mothers in the low-risk group were normally distributed. In the high-risk group, the data for representational gesture rate were normally distributed. However, the data for deictic and conventional rates violated the assumption of normality, \( W(8), = .64, p = .000 \) and \( W(8), = .80, p = .026 \) respectively.

Given that profile analysis is sensitive to outliers (Tabachnick & Fidell, 2007), the deictic gestures data were first screened for statistical outliers. Procedures recommended by Van Selst and Jolicouer (1994) for identifying and eliminating outliers in small sample sizes were followed\(^1\) resulting in one case being identified and removed for all three dependent variables. The removal of the outlier resulted in normal distribution for deictic and conventional gestures: \( W(7), = .84, p = .100 \) and \( W(7), = .82, p = .069 \) respectively. Data for representational gestures remained normally distributed. The assumption of homogeneity of variance was violated for deictic gestures.

After removing the outlier, a profile analysis was conducted to compare the profile of maternal gesture types. Covariance matrices were equal across groups and the test for sphericity was not violated. Using the Wilks criterion, the profiles seen in Figure 11 did not deviate significantly from parallelism, \( F(2, 13) = .76, p = .488 \), partial \( \eta^2 = .12 \), indicating that the profile of types of maternal gestures used by mothers of high-risk infants was not significantly different than that of mothers of low-risk infants. The homogeneity of variance assumption was not met; therefore, the levels test must be interpreted with caution. The levels test revealed no

\(^1\)The mean rate of deictic gestures and standard deviation for mothers of high-risk infants were computed \((M = 3.68, SD = 1.15)\). The case with the highest rate of deictic gestures \((6.42/min)\) was temporarily removed and the mean and standard deviation for the remaining seven cases were computed \((M = 3.29, SD = .31)\). The removed case was then re-included in the sample. The highest and lowest rates of deictic gestures were examined to determine whether these fell outside the recommended cut-off values for a sample size of eight using the modified recursive procedure, which was +/- 4.475 standard deviations from the group mean. Therefore, cases with rates outside the range of 1.90 and 4.68 would be considered statistical outliers. The lowest rate in the sample was 2.96/min. and the highest rate in the sample was 6.42/min. The case with a rate of 6.42 deictic gestures was identified as a statistical outlier and removed.
statistically significant differences among the groups when maternal gesture rates were averaged over the three types (i.e., deictic, conventional, representational), $F(1, 14) = .01, p = .940$. When averaged over groups, however, the dependent variables were found by Hotelling’s criterion to deviate significantly from flatness $F(2, 13) = 32.34, p = .000$, partial $\eta^2 = .83$, indicating that the three gesture types used by mothers were not used at the same rates.

**Types of Gestures—Mothers**

![Profile Plot for Mean Rates of Types of Maternal Gestures.](image)

*Figure 11. Profile Plot for Mean Rates of Types of Maternal Gestures.*

To investigate the source of the deviation from flatness, three paired-samples $t$ tests were conducted to compare maternal rate of deictic and conventional gestures, conventional and representational gestures and deictic and representational gestures. Because the profiles of types of gestures of mothers in
each group were not significantly different, the mean rates of each type of gesture were collapsed across groups. Level of significance $\alpha = .05$ was achieved by setting $\alpha$ for each test at .017 (.05 divided by 3 comparisons). The results indicated that mothers used a significantly higher mean rate of deictic gestures ($M = 3.44, SD = .88$) than conventional ($M = 2.05, SD = 1.05$), $t(15) = 3.54, p = .003, d = .89$ and representational gestures, ($M = .98, SD = .59$), $t(15) = 8.48, p = .000, d = 2.12$. In addition, mothers used a higher rate of conventional than representational gestures, $t(15) = 3.30, p = .005, d = .83$.

**Functions of gestures.** To investigate the three communicative functions of maternal gestures, a profile analysis was conducted to compare mothers of low- and high-risk infants. The independent variable was infant group (i.e., mothers of high- and low-risk infants). The dependent variable was the communicative function (i.e., behaviour regulation, social interaction, joint attention). The mean rates and standard deviations for the three communicative functions are displayed in Table 17.

Table 17

<table>
<thead>
<tr>
<th>Function</th>
<th>Mothers of High-Risk</th>
<th>Mothers of Low-Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>Min–Max</td>
</tr>
<tr>
<td>Behaviour Regulation</td>
<td>2.00 (.72)</td>
<td>1.05–3.35</td>
</tr>
<tr>
<td>Social Interaction</td>
<td>1.67 (.78)</td>
<td>.97–3.10</td>
</tr>
<tr>
<td>Joint Attention</td>
<td>3.19 (.95)</td>
<td>2.09–4.53</td>
</tr>
</tbody>
</table>

The data for all variables were normally distributed for both groups and the homogeneity of variance assumption was met. Covariance matrices were equal across groups and sphericity was not violated. Using Wilks’ criterion, the profiles seen in Figure 12 did not deviate significantly from parallelism, $F(2, 14) = .88, p = .435$, partial $\eta^2 = .11$, indicating that there were no significant differences between groups with respect to gesture use for the three communicative functions. For the
levels test, no statistically significant differences were found among the groups when gestures rates were averaged across the three functions (i.e., behaviour regulation, social interaction, joint attention): $F(1, 15) = .42, p = .529$. When averaged across groups, however, the dependent variables were found by Hotelling’s criterion to deviate significantly from flatness $F(2, 14) = 23.07, p = .000$, partial $\eta^2 = .77$ indicating that mothers used gestures for the three communicative functions at different rates.

**Communicative Function of Gestures – Mothers**

![Profile Plot for Mean Rates of Communicative Functions of Maternal Gestures](image)

Figure 12. *Profile Plot for Mean Rates of Communicative Functions of Maternal Gestures.*

To investigate the source of the deviation from flatness, three paired-samples $t$ tests were conducted to compare maternal rate of gestures used for behaviour regulation and social interaction, behaviour regulation and joint attention and social interaction.
interaction and joint attention. Because the profiles of maternal gestures used for each communication function in each group were not significantly different, the mean rates of each gesture type were collapsed across groups. Level of significance $\alpha = .05$ was achieved by setting $\alpha$ for each test at .017 (.05 divided by 3 comparisons). The results indicated no significant difference between the rate of gesture use for behaviour regulation ($M = 1.70, SD = .87$) and social interaction ($M = 1.56, SD = .63$), $t(16) = .571, p = .576$. However, results showed that mothers used gestures for joint attention ($M = 3.39, SD = .91$) at a significantly higher rate than for both behaviour regulation $t(16) = 4.67, p = .000, d = -1.13$ and social interaction $t(16) = 7.00, p = .000, d = -1.70$.

**Symbolic play acts.** The rate of symbolic play acts was compared to investigate the hypothesis that mothers of high-risk infants would use fewer symbolic play acts than mothers of low-risk infants. The means and standard deviations for rates of symbolic play acts for mothers in each group are displayed in Figure 13.

![Maternal Symbolic Play Acts](image)

*Figure 13. Mean Rates and Standard Deviations of Maternal Symbolic Play Acts.*
A Mann-Whitney U test was conducted to compare rate of symbolic play acts in mothers of low-risk infants ($M = .82, SD = .57$) with that of the mothers of high-risk infants ($M = 1.45, SD = .57$). The rates of symbolic play acts were normally distributed for the low-risk group but the assumption of normality was violated for the high-risk group. The test was significant: $z = -2.11, p = .034, r = .53$. Mothers of high-risk infants had an average rank of 11.75, while mothers of low-risk infants had an average rank of 6.59 during naturalistic play interactions with their infants, indicating that mothers of high-risk infants use symbolic play acts at a significantly higher rate than mothers of low-risk infants.

**Maternal gesture strategies used to augment spoken language.** A profile analysis was conducted to compare the profiles of the three gesture strategies that mothers used to augment their spoken language. The independent variable was infant diagnostic group (i.e. high- and low-risk infants). The dependent variable was gesture strategy (i.e., the gesture emphasizes, disambiguates, or adds to the language produced). The mean rates and standard deviations for the three strategies are displayed in Table 18.

Table 18

<table>
<thead>
<tr>
<th>Gesture Strategy</th>
<th>Mothers of High-Risk</th>
<th>Mothers of Low-Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>Min–Max</td>
</tr>
<tr>
<td>Emphasize</td>
<td>4.0 (.89)</td>
<td>2.66–5.27</td>
</tr>
<tr>
<td>Disambiguate</td>
<td>1.12 (.91)</td>
<td>.31–2.84</td>
</tr>
<tr>
<td>Add</td>
<td>.55 (.33)</td>
<td>.22–1.22</td>
</tr>
</tbody>
</table>

The data for all variables were normally distributed for both groups. Tests for homogeneity of variance and equality of covariance matrices were not violated. However, the test for sphericity was violated. Using the Greenhouse-Geisser adjustment, the profiles seen in Figure 14 did not deviate significantly from parallelism, $F(1.34, 20.12) = .02, p = .944$, partial $\eta^2 = .01$, indicating that there were
no significant differences between groups with respect to the gesture strategies mothers used to augment their spoken language. For the levels test, no statistically significant differences were found when rates were averaged across the three gesture strategies (i.e., emphasize, disambiguate, or add) \( F(1, 15) = .01, p = .920 \), indicating that the two groups of mothers did not differ with respect to rates of gesture strategies used to augment language. When averaged across groups however, the dependent variables were found by the Greenhouse-Geisser criterion to deviate significantly from flatness \( F(1.34, 20.12) = 89.58, p = .000 \), partial \( \eta^2 = .86 \) indicating a significant difference in the three gesture strategies used to augmented spoken language; that is, individual gesture strategies were not used at similar rates.

**Maternal Gesture Strategies Used to Augment Spoken Language**

![Profile Plot for Mean Rates Showing Maternal Gesture Strategies Used to Augment Spoken Language](image)

*Figure 14. Profile Plot for Mean Rates Showing Maternal Gesture Strategies Used to Augment Spoken Language*
To investigate the source of the deviation from flatness, three paired-samples t tests were conducted to compare the three gesture strategies. Because both groups of mothers showed similar profiles with respect to the gesture strategies mothers used to augment language, the mean rates of the three strategies were collapsed across groups. Level of significance $\alpha = .05$ was achieved by setting $\alpha$ for each test at .017 (.05 divided by 3 comparisons). Results indicated that mothers used gestures more often to emphasize ($M = 4.01, SD = 1.08$) than to disambiguate ($M = 1.11, SD = .67$), $t(16) = 8.62, p = .000, d = 2.09$, or add ($M = .59, SD = .31$), $t(16) = 12.71, p = .000, d = 3.08$ to their spoken language. In addition, mothers used gestures more often to disambiguate their spoken language ($M = 1.11, SD = .67$) than to add to ($M = .59, SD = .31$) their spoken language $t(16) = 3.13, p = .006, d = .76$.

**Maternal prompts to encourage infant gesture use.** Data for the three dependent variables for maternal prompts (i.e., rates of model, verbal, and physical prompts) were collapsed into one variable (i.e., rate of maternal prompts) because of the limited data in the verbal and physical prompt categories. Therefore, the hypothesis predicting that mothers of high-risk infants would use a higher rate of physical prompts than mothers of low-risk infants could not be tested. When the three dependent variables were collapsed to form the new dependent variable—rate of maternal prompt—the data were distributed normally for each group and the test for homogeneity of variance was not violated. Figure 15 displays the mean rates and standard deviations for maternal prompts by group.
Figure 15. Mean Rates and Standard Deviations of Maternal Prompts to Encourage Infant Gesturing.

An independent-samples t test was conducted to explore the overall rate of maternal prompts with infants in a naturalistic play context. The test was not significant: $t(15) = .69, p = .498, d = .34$. No significant difference was detected between mothers of high-risk infants ($M = 1.22, SD = .69$) and mothers of low-risk infants ($M = 1.44, SD = .63$) in the maternal rate of prompts used with infants in a naturalistic, home context.

In summary, mothers of high- and low-risk infants were more similar than different with respect to gestures and related behaviours. Group comparisons of maternal gesture rates and profiles of types and communication functions of gestures revealed no significant differences. Both groups of mothers: (a) used gestures with their infants at similar rates, (b) had similar profiles of gesture types, and (c) had similar profiles of communicative functions. With respect to types, mothers used primarily deictic gestures, followed by conventional, then representational gestures. With respect to communicative functions, mothers
gestured primarily for joint attention purposes using gestures for behaviour regulation and social interaction at similar rates. Notably, a group comparison of rates of symbolic play revealed that mothers of high-risk infants performed symbolic play acts at a significantly higher rate than mothers of low-risk infants. Mothers in both groups had similar profiles with respect to how they used gestures to augment their spoken language. Maternal gestures served primarily to emphasize spoken language. Mothers used fewer gestures to disambiguate and fewer still to add to their spoken language. With respect to prompting infants to gesture, mothers in both groups used prompts at similar rates.

**Maternal responsiveness to directed versus non-directed infant gestures.** A post-hoc question was developed in light of the finding that high-risk infants used a significantly higher rate of non-directed gestures than low-risk infants. It was hypothesized that mothers of infants at risk for ASD may be more likely to respond to gestures that were directed than gestures that were not directed. To investigate this hypothesis, a Wilcoxon Signed Rank test was conducted to compare responses of mothers of high-risk infants to directed and non-directed infant gestures. Contrary to the prediction, there was no significant difference between mothers’ responses to directed and non-directed infant gestures, $z = -.51, p = .612$.

**Discussion**

Theoretical and empirical evidence supports the assertion that infant–mother interactions provide a critical arena within which infants typically develop social, communication, and play behaviours (Goldin-Meadow, Goodrich, Sauer, & Iverson, 2007; Iverson et al., 1999). These interactions are reciprocal in nature; that is, maternal behaviours affect infant behaviours and vice versa (Goldin-Meadow et al., 2007; Grimminger et al., 2010; Iverson et al., 2006; Iverson et al., 1999; Namy et al., 2000). Thus, in order to understand the nature of gesture deficits in infants at risk for ASD, it is equally important to examine similar communicative behaviours in their mothers. The primary objective of the current study, therefore, was to examine communicative and symbolic play gestures in both infants and their mothers.
For children with ASD, impairments in gesture use have been well described in the literature. These impairments, which include delays in the acquisition of gestures as well as a unique pattern of deficits, are clearly evident by preschool age, but relatively little is known about the development of gesture use prior to that age. The primary objective of the current research study was thus twofold. First, to determine whether impaired gesture use, as seen in older children with ASD, is evident in the prelinguistic period of development in infants who are at high risk for ASD but who have not yet been diagnosed. Second, if impairments can be detected at this young age, to determine whether there is a pattern or profile of gesture usage that differs from that seen in typically developing infants (i.e., those who are at low risk for ASD). Clinically speaking, determining whether high-risk infants demonstrate delays in the development of gestures and/or patterns of gesture use that are different than those seen in infants not at risk for ASD has possible implications for identification and early intervention. Scientifically speaking, if profiles are different, understanding which gesture types and functions differ may contribute to a better theoretical understanding of the mechanisms that underlie infants’ acquisition of these early communicative behaviours, and may inform an understanding of the earliest emergence of ASD.

For the current project, the question of delays and/or differences in patterns of gesture use was addressed by comparing infants at risk for ASD to low-risk infants on their rate of usage and inventory of gestures (communicative and symbolic play) as well as their pattern of gesture directedness, type and function. As stated previously, seven of the eight infants identified as having increased risk for ASD went on to meet criteria for ASD and one was identified as having language delays. It was predicted that high-risk infants would show both delayed and different gesture patterns relative to low-risk infants. Most predictions were supported.

**Overview of Contributions: Infants**

This study makes two novel contributions to the current infant literature. First, infants at risk for ASD showed higher rates of non-directed gestures than did low-risk controls. Second, high-risk infants showed patterns of gesture use—with
respect to directedness, type and function—that differed from those seen in the low-risk infants. These findings converge to demonstrate that high-risk infants have divergent patterns of gesture use relative to low-risk infants. These patterns were consistent across clinic and home contexts. Moreover, in addition to divergent patterns of gesture use, high-risk infants showed delayed gesture use. Relative to low-risk infants, evidence of delays in the acquisition of gestures in high-risk infants included: (a) low frequency of gesture use, (b) low frequency of symbolic play acts (in the home context only), and (c) a smaller inventory of communicative and symbolic play gestures based on parent report.

Findings for infants will be discussed in the context of our current knowledge of gesture use in infants later diagnosed with ASD. Evidence of divergent patterns of gesture use will be presented first: (a) high rate of non-directed gestures, and (b) different profiles of directedness, type, and functions of gesture use. Evidence of delayed gesture development will be discussed next: (a) low rates of communicative and symbolic gesture use, and (b) smaller inventories of communicative and symbolic play gestures based on parent reports. Finally, theoretical and clinical implications for infant findings will be discussed.

**High rate of non-directed gestures.** It was predicted that infants at risk for ASD would have a higher rate of non-directed gestures than low-risk infants. As explained previously, non-directed gestures were those produced without evidence of *directedness*. Evidence of directedness included giving an object to a person, or producing a gesture coordinated with eye gaze, vocalization, and/or physical contact. In both clinic and home contexts, high-risk infants used gestures that were not directed to a communicative partner at a significantly higher rate than low-risk infants. This finding was accompanied by large effect sizes in clinic and home contexts. To date, no other studies have examined non-directed gesture use. This is likely because gestures produced but not directed to a person would typically not be seen as communicative. However, there is converging evidence in the literature to support the finding of high rates of non-directed gesture use in infants at risk.

It is well documented that preschool-aged children with ASD have difficulty coordinating modes of communication; in particular, directing their communication
with gaze shifts (Phillips et al., 1995; Stone et al., 1997; Wetherby et al., 1998). Shumway and Wetherby (2009) examined the coordination of modes of communication in 18- to 24-month-olds with ASD. Relative to typical toddlers, those with ASD had a significantly smaller proportion of communicative acts (including gestures) that were coordinated with vocalization. Surprisingly, no group differences were found in the proportion of communicative acts coordinated with gaze.

The Shumway and Wetherby (2009) study also compared toddlers with ASD and those with developmental delay. Finding no group differences in coordination of communication modes, they argued that lack of coordination of modes may not be a core deficit of ASD. However, it is important to note that only communicative acts that were directed were included in the analysis; that is, a communicative act had to include at least two modes of communication (e.g., gesture and eye gaze, gesture and vocalization, vocalization/words and gaze). By definition, then, gestures that were not coordinated with a means to direct them were excluded. These gestures would be analogous to non-directed gestures in the current study. Had Shumway and Wetherby included non-directed gestural acts, it remains possible that differences between toddlers with ASD and those with developmental delay may have emerged. Nevertheless, difficulties were reported in coordinating modes of communication in toddlers with ASD. The high rates of non-directed gesture use found in the current study suggest that signs of difficulty with coordinating communicative modes may be evident much earlier in development than previously reported.

In addition to the difficulty coordinating modes of communication described above, high-risk infants have demonstrated delays in the acquisition of some component skills (i.e., visual attention shifting, vocalizations) that are later required to direct gestures (Dawson, Osterling, Meltzoff, & Kuhl, 2000; Gernsbacher, 2004; Iverson & Wozniak, 2007; Landa et al., 2007; Landry & Bryson, 2004). Infants later diagnosed with ASD have been shown to have difficulty with disengaging and shifting visual attention as early as six months of age (Landry & Bryson, 2004) relative to low-risk controls. Thus, producing a gesture without coordinated eye
gaze may be explained, in part, by an elementary difficulty in disengaging and/or shifting visual attention between people and objects. However, in the present study, directedness did not require directed gaze; gestures combined with vocalizations were also considered directed. Core delays in the development of vocal output in infants later diagnosed with ASD may also account for challenges combining gestures with vocalizations. High-risk infants have been described as having delayed onset of babbling (Iverson & Wozniak, 2007), limited babbling (Dawson et al., 2000, Gernsbacher, 2004), and limited inventories of consonants relative to typically developing infants (Landa et al., 2007). Producing gestures without coordinated vocalizations may thus be related, to some extent, to delays in the development of vocalizations and speech sounds.

Infant siblings at risk for ASD also show differences in the early coordination of the developmental systems (e.g., vocal–motor systems; Iverson & Wozniak, 2007) involved in the later production of directed gestures. Typically developing infants predictably show an age-related increase in coordinated arm movements and vocalizations (Iverson & Fagan, 2004; Iverson, Hall, Nickel, & Wozniak, 2007). Iverson & Wozniak (2007) compared rhythmic arm movements that co-occurred with vocalization/babbling in high- and low-risk infants between the ages of 5 and 14 months. While typically developing infants showed a significant increase in rhythmic arm movements with a peak frequency observed just prior to the onset of babbling, high-risk infants showed a more modest increase in rhythmic arm movements (Iverson & Wozniak, 2007). Results from the Iverson & Wozniak (2007) study suggest that infants at risk for ASD may have difficulty in the early coordination of motor and vocal systems. This early difficulty in coordinating these systems may thus contribute to the difficulty producing a gesture coordinated with vocalization observed in the current sample of infants.

**Understanding why high-risk infants do not direct gestures.** Several developmental systems—including vocal production, visual attention shifting, and motor control—emerge developmentally earlier than the onset of gesture use and are arguably required for the production of a directed gesture. Theoretically, the high rate of non-directed gestures may be an outcome of delays in the development
of each component system and/or the subsequent integration of the systems to produce directed gestures. The coordination/integration of multiple developmental systems (i.e., visual–motor or vocal–motor or visual–vocal–motor), the constituent parts of which are impaired in infants later diagnosed with ASD, may be fundamental to the production of gestures paired with gaze or vocalization. In other words, a disruption in the coordination/integration of developmental systems may be central to understanding why infants at risk for ASD are not directing gestures as competently as their low-risk peers.

Support for this interpretation can be found in developmental psychology’s dynamic systems theory (Thelen & Smith, 1994), a theoretical framework contending that complex developmental systems (i.e., language, cognition, motor) are self-organizing and have evolving patterns of dynamic stability rather than a linear progression toward developmental maturity. Developmental transition points are purported to be times of instability in normal development and, as such, are susceptible to decoupling as constituent skills become more stable. Systems then increasingly self-organize, recouple, and evolve as a stable dynamic system. Dynamic systems theory was first used to conceptualize the complex system of motor development in typical infants. Thelen and Smith used the example of crawling to illustrate this model. Once infants begin to crawl, the motor pattern appears well established and remains consistent for a period of months. As infants begin to stand and walk, the established pattern becomes destabilized as new patterns develop.

Dynamic systems theory has also been used to conceptualize aspects of communication development in typical infants. Communication is a complex developmental system that—minimally—involves vocal, visual, and motor domains. In the developing communication system, these domains are temporally linked in typically developing infants (e.g., Butcher & Goldin-Meadow, 2000; Pizzuto, Capobianco, & Devescovi, 2005). Parlade and Iverson (2011) showed a decoupling in the coordination of communicative behaviours in typically developing infants at the time of their individual vocabulary spurts. Although all infants exhibited bouts of communication with coordinated modes (i.e., infants combined language,
vocalizations, gestures, and facial expressions), these coordinated bouts significantly decreased prior to spurts in expressive vocabulary then rebounded afterward. If infants at risk for ASD experience unstable patterns of use in the constituent components of vocal, visual attention, and motor domains, a decoupling at developmental transition points may result in disruptions to the self-organization of a unified communication system. Vulnerable periods in normal development, then, may be particularly vulnerable periods for infants with ASD. High-risk infants may require more practice with constituent skills and more time for these developmental systems to self-organize.

Difficulty coordinating developmental systems may provide some explanation as to why infants with ASD might have difficulty directing their gestures through the use of eye gaze or vocalization. However, infants in this sample were also credited for directing if they demonstrated other behaviours such as producing a gesture in response to a comment or while touching someone. Arguably, these behaviors are less likely to be susceptible to destabilization. Thus, an alternate theoretical interpretation is necessary. Directing a gesture involves understanding that communication must be received by a communicative partner. In typical development, this knowledge is expressed in the development of joint attention behaviours.

Early joint attention behaviours have been theoretically (Baron-Cohen, 1989; 1991; Tomasello, 1995) and empirically (Charman et al., 2000) implicated as precursors for the development of theory of mind abilities. Theory of mind is a construct broadly defined as the ability to attribute mental states to others and to use this knowledge to predict others’ behaviour, intentions, and actions. Joint attention behaviours refer to sharing, following, and directing attention to objects. Thus, joint attention behaviours encompass a range of visual, gestural, and verbal behaviours, including initiating and responding to joint attention bids, gaze shifting and following, and shared attention in play. Deficits in these joint attention behaviours seen in young children with ASD have been theorized to be one of the early manifestations of the later theory of mind deficits seen in older children with ASD (Baron-Cohen, 1989; 1991; Charman et al., 2000). High rates of non-directed
gesture use in infants in the current sample may be indirect evidence of an underlying deficit in joint attention behaviours.

High-risk infants in the current sample directed at least some of their gestures in both home and clinic contexts. Underlying deficits in joint attention behaviours provide a plausible explanation for why high-risk infants did not direct gestures, but they do not offer as clear an interpretation of why infants did direct at least some of their gestures. It is more likely that directed gesturing seen in the current sample of high-risk infants is suggestive of increased stability in constituent skills and emergent recoupling of visual–vocal–motor developmental systems.

**Divergent profiles of gesture use.** The second major contribution of this study to the infant literature is the finding that infants at risk for ASD showed three profiles of gesture use that diverged from the profiles seen in the low-risk group. Divergent profiles were found for gesture directedness, type, and function. These findings were robust in that all profiles for high-risk infants diverged from those seen in low-risk infants in both clinic and home contexts, with large effect sizes. These divergent patterns of gesture use, previously reported in older children with ASD, are evident by 15 months of age.

**Divergent profiles of directedness.** High-risk infants had a profile of directed versus non-directed gesture use that was significantly different from that seen in low-risk infants. This finding was consistent across clinic and home settings with large effects for both contexts. Although findings supported the prediction that groups would have different profiles, the specific profile that was predicted for the high-risk group was not supported. High-risk infants were expected to have a low rate of directed gestures and a high rate of non-directed gestures. However, the high-risk infants showed no significant difference in directed versus non-directed gesture rates in either context. That is, as a group high-risk infants used directed and non-directed gestures at similar rates across clinic and home contexts, whereas low-risk infants used higher rates of directed gestures in both contexts (see Table 19). This finding prompted and an examination of individual case profiles to determine the proportion of non-directed gestures (relative to directed gestures) produced by each infant.
As can be seen in Table 12 an inspection of the individual case profiles of directedness revealed that all high-risk infants who were later diagnosed with ASD had proportions of non-directed gestures greater than 40%. Moreover, four infants produced non-directed gestures as the majority of their gestures with proportions ranging 56% to 70%. None of the infants in the low-risk group had proportions of non-directed gestures greater than 40%. It is important to note that the infant with the highest proportion of non-directed gestures in the low-risk group (case 9; 39.7% non-directed gestures) also had an elevated ADOS score (one point below cut-off for ASD) at 18 months of age suggesting possible concerns with social communication. This case was the only infant with elevated scores but diagnostic status at 24 months was not determined due to the family’s withdrawal from the longitudinal study. The pattern of having a substantial proportion of non-directed gestures in all of the high-risk infants later diagnosed with ASD lends support to the interpretation that this profile may signal increased vulnerability to the social communication deficits seen in ASD. However, without longitudinal data or a comparison group of infants with other developmental delays it remains possible that this pattern may be present in developmentally delayed infants, or earlier in younger, typical infants.

To investigate the possibility that even if non-directed gestures were included as gestures that high-risk infants would continue to show lower rates of combined gestures, a post-hoc comparison of combined directed and non-directed gestures was conducted. Contrary to the hypothesis, the frequency of combined gestures was not significantly different across groups. High-risk infants in this sample thus gestured at similar rates to low-risk infants when directed and non-directed gestures were considered. Notably, as is reflected in the individual case profiles above, these infants failed to direct a substantial proportion of their gestures to a partner.

With respect to group differences, not only did high-risk infants use significantly more non-directed gestures, they used significantly fewer directed gestures overall relative to the low-risk group in both clinic and home contexts. This result converges with findings from retrospective studies, which have demonstrated that, by 12 months of age, infants later diagnosed with ASD gesture less frequently
than typically developing infants in naturalistic home settings (Adrien et al., 1993; Maestro et al., 2001; Osterling et al., 2002). The decreased rate of communicative gestures found in this sample is also consistent with previous prospective studies that have demonstrated decreased frequency of gesture use in slightly older infants (Landa et al., 2007; Shumway & Wetherby, 2009; Wetherby et al., 2007; Wetherby et al., 2004).

**Divergent profiles of gesture types.** The prediction that high-risk infants would have a different profile of types of gestures than low-risk infants was supported by this research. Profiles differed across contexts with large effect sizes. This finding is consistent with the literature showing that slightly older infants (i.e., 18–24 months of age) with ASD have a profile of gesture types that differs from those of typically developing infants and infants with DD (Shumway & Wetherby, 2009). However, the profile of types of gestures in the current high-risk group differed somewhat from those predicted.

Results did not support the hypothesis that high-risk infants would use more conventional than deictic gestures. The rationale for this prediction was that the category of conventional gestures includes more primitive gestures (contact and emotive). High-risk infants were expected to use more of these earlier-developing gestures thereby elevating the overall rate of conventional gestures. Increased use of these earlier-developing gestures has been demonstrated in 18- to 24-month-old infants with ASD: Shumway & Wetherby, (2009) reported increased use of contact-without-object gestures in their ASD group compared to both typically developing infants and those with developmental delay. Unlike low-risk infants in this study who used primarily deictic gestures with fewer conventional gestures, high-risk infants used these gesture types at similar rates in both contexts (see Table 19). However, it remains possible that there could be qualitative differences in the sophistication of the conventional gestures used, which elevated the rates to be equal.

A group comparison of the rate of deictic gestures indicated that high-risk infants used significantly fewer deictic gestures than low-risk infants in both clinic and home contexts. These data showed that not all types of gestures were produced
at significantly lower rates relative to low-risk infants, suggesting a unique profile of gesture types in high-risk infants. Findings from this study showing a specific deficit in the use of deictic gestures are consistent with results from retrospective studies (Clifford & Dissanayake, 2008; Clifford et al., 2007; Maestro et al., 2001; Mars et al., 1998; Osterling & Dawson, 1994) and prospective studies (Brian et al., 2008; Shumway & Wetherby, 2009; Wetherby et al., 2004). Shumway and Wetherby (2009) also showed that, compared to both typical infants and those with developmental delays, 18- to 24-month-old infants with ASD had a specific deficit in the use of deictic gestures.

**Divergent profiles of gesture functions.** Results from this research supported the hypothesis that high-risk infants would have a significantly different profile of communicative functions in their gesture use relative to low-risk infants, which occurred in both clinic and home contexts. There are no known studies in the literature that have examined the communicative functions of gestures in infants at risk for ASD. However, findings were consistent with other prospective studies that have examined the functions of communicative acts (including gestures), demonstrating that older infants with ASD have a unique pattern of communicative functions relative to typically developing children (Shumway & Wetherby, 2009; Wetherby et al., 2007).
Table 19.

Summary of within-group profiles of directedness, types, and functions of gestures for high- and low-risk infants in clinic and home contexts.

<table>
<thead>
<tr>
<th>Profiles</th>
<th>High-Risk</th>
<th>Low-Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Directedness</td>
<td>Clinic: [d+] = [d-], Home: [d+] = [d-]</td>
<td>Clinic: [d+] &gt; [d-], Home: [d+] &gt; [d-]</td>
</tr>
<tr>
<td>Type</td>
<td>Clinic: [D] = [C], Home: [D] = [C]</td>
<td>Clinic: [D] &gt; [C], Home: [D] &gt; [C]</td>
</tr>
<tr>
<td>Function</td>
<td>Clinic: [BR] &gt; [JA], [BR] = [JA], [BR] = [JA], [BR] = [JA]</td>
<td>Home: [BR] = [SI], [BR] &gt; [SI], [BR] &gt; [SI], [BR] = [SI]</td>
</tr>
<tr>
<td></td>
<td>Clinic: [JA] = [SI], [JA] = [SI], [JA] &gt; [SI], [JA] &gt; [SI]</td>
<td>Home: [JA] &gt; [SI], [JA] &gt; [SI], [JA] &gt; [SI]</td>
</tr>
</tbody>
</table>

Note. Directed (d+), non-directed (d-), deictic (D), conventional (C), behaviour regulation (BR), social interaction (SI), joint attention (JA).

With respect to the specific profile of functions, high-risk infants were expected to use gestures more often for behaviour regulation than for joint attention or social interaction. As can be seen in Table 19, results generally supported this prediction, although somewhat different profiles of functions were observed in home and clinic contexts. High-risk infants used gestures more for behaviour regulation than for joint attention in the clinic context but this difference only approached significance in the home context. In contrast, low-risk infants gestured for behaviour regulation and joint attention at similar rates in both clinic and home contexts. High-risk infants used gestures more for behaviour regulation than social interaction in both contexts, whereas low-risk infants showed this profile only in the clinic context. High-risk infants used gestures for joint attention and for social interaction at similar rates in both contexts, whereas low-risk infants used more gestures for joint attention than for social interaction in both contexts. The profile of communicative functions in high-risk infants in this sample converges with findings from other studies. Shumway and Wetherby, (2009) reported a higher
proportion of non-verbal communicative acts for behaviour regulation than social interaction and joint attention in their high-risk sample.

It is important to note that communicative functions are sensitive to the activity within which gestures are sampled. Although every effort was made to uniformly sample functions in each context, activities in the clinic assessment differed somewhat from the home context. For example, the home context included a peek-a-boo game whereas the CSBS-DP (Wetherby & Prizant, 2002) did not. In addition, the adult communicative partner differed in the two contexts (i.e., examiner vs. parent), which may have contributed to somewhat different rates of gesture functions across contexts. Despite somewhat different patterns of communicative functions in clinic and at home for both groups, the profile of functions for high-risk infants was consistently different from that seen in low-risk infants.

When each communicative function was compared between the groups, high-risk infants used significantly fewer gestures for joint attention than did low-risk infants in both settings. High-risk infants in this sample did not use fewer gestures for behaviour regulation or social interaction relative to low-risk infants. This finding differs from the group differences in these functions reported by Shumway and Wetherby (2009). One possible explanation for these disparate findings is the age of the infants. In the Shumway and Wetherby study, infants ranged in age from 18–24 months. If, at 15 months of age, gestural rates for these functions are not different, as was found in this sample, the Shumway and Wetherby findings may be indicative of a widening developmental gap between infants at risk for ASD and infants who are typically developing. Longitudinal research comparing the developmental trajectories of infants with ASD has revealed a pattern of reduced rate of development or *plateauing* that is distinct from that observed in those with developmental delay (Landa et al., 2006; Ozonoff et al., 2010).

**Understanding why infants at risk for ASD have divergent gesture profiles.** In understanding why infants at risk for ASD showed divergent gesture profiles, it is useful to consider factors that may have contributed to the two specific deficits seen in high-risk infants. High-risk infants differed primarily in their use of
deictic gestures and gestures used for joint attention purposes. Unlike other types of gestures that carry the semantic referent in the gesture, deictic gestures are triadic (i.e., require the coordination of attention between people and objects). Similarly, by definition, gestures produced for the communicative function of joint attention are also triadic. Thus, selective deficits in triadic attention may be at the core of both findings.

Developmentally speaking, dyadic attention emerges earlier than triadic attention (Trevarthen & Hubley, 1978; Newson & Newson, 1975). It has been argued that early difficulties with dyadic attention may underlie later difficulties with triadic attention in ASD (Clifford & Dissanayake, 2008). The present results support this argument, in part, given that high-risk infants differed only on deictic gestures and those used for joint attention. Moreover, there were no group differences in social interaction, which is wholly dyadic. Other studies have also shown either no difference in rates of gestures for social interaction (Colgan et al., 2006) or an increased proportion of communicative acts for social interaction relative to typically developing infants (Shumway & Wetherby, 2009).

Notably, high-risk infants in the current sample were not different from low-risk infants with respect to gesturing for behaviour regulation, which involves both dyadic (e.g., push away to protest) and triadic (point to request) attention. The similar rate of gestures for behaviour regulation across groups suggests that high-risk infants produced at least some gestures requiring triadic attention. It is thus possible that other factors may have contributed to the lack of group differences in gestures for behaviour regulation. High-risk infants may have lower social motivation to share attention. In addition, gestures for behaviour regulation are more likely to be met with more immediate, contingent, and tangible responses from mothers than those used for joint attention. Taken together, these factors may have contributed to high-risk infants showing similar rates of behaviour regulation gestures, but lower rates of joint attention gestures, relative to low-risk infants. Further examination of rates of dyadic versus triadic gestures for behaviour regulation may be useful in determining the validity of this argument.
Evidence of delay in gesture acquisition. In addition to the findings demonstrating different gesture profiles, high-risk infants showed evidence of delay in the acquisition of gestures. Two findings, namely, relatively lower rates of symbolic acts and smaller inventories of communicative and symbolic play gestures confirm and extend our knowledge of gesture acquisition in infants at risk for ASD.

Symbolic play acts. It was expected, based on previous evidence of lower rates of play relative to 18- to 24-month-old infants with typical development (Shumway & Wetherby, 2009; Wetherby et al., 2007), that high-risk infants would have lower rates of symbolic play acts than low-risk infants. This hypothesis was borne out, but only for the home context. Differences in the presentation of play opportunities in each context may have resulted in somewhat disparate findings in symbolic play rates across setting. First, a more controlled presentation of play opportunities occurred in the clinic context than the home context. In the clinic context, toys for symbolic play were presented to the child in a standardized administration of the CSBS-DP (Wetherby & Prizant, 2002). If infants did not demonstrate some symbolic play with the initial set of pretend play toys, additional toys were not presented. At home, although efforts were made to control the length of each of the six activities, mothers often returned to the symbolic play toys as they engaged their infant in interactions. Second, standardized administration of the CSBS-DP requires the examiner to wait for the infant to initiate prior to modeling symbolic play acts, whereas in the home context, mothers were not instructed to adjust their play behaviour. Moreover, infants in both groups may have played differently with the examiner than with their mother. Both groups of infants had a higher rate of play at home than in the clinic. Nonetheless, by 15 months of age, high-risk infants had lower rates of symbolic play acts in a clinical context relative to low-risk infants of the same age.

Parent-reported gestures. As predicted, high-risk infants had a smaller inventory of gestures as reported by parents. The number of early (i.e., communicative) and late (i.e., symbolic play) gestures was significantly lower in the high-risk group. This finding is consistent with the prospective literature showing smaller inventories of communicative and symbolic play gestures in toddlers with
ASD (Charman, Drew, Baird, & Baird, 2003; Luyster, Qui, et al., 2007; Luyster, et al., 2008) and in 12-month-old infants at risk for ASD, relative to low-risk controls (Mitchell et al., 2006). Parent report offers a unique perspective, because it samples a wider range of gestures than was sampled in the infant–mother interaction. In addition, mothers reported on gestures they would have observed in naturalistic settings. Although this measure does not provide information regarding frequency and quality of gestures, it confirms that mothers were able to report gesture inventories that reflected the gesture impairments observed objectively in the same sample of infants.

**Implications of Findings: Infants**

**Early identification.** Two key findings related to deficits in gesture use in 15-month-old, high-risk infants identified in the current research are pertinent to front-line clinicians in the early identification of infants at risk for social communication and language difficulties associated with ASD. First, high-risk infants showed a constellation of three patterns of gesture use that differed from the patterns seen in low-risk infants which may suggest vulnerability to ASD: (a) higher rates of non-directed gestures and lower rates of directed gestures, (b) specific deficits in the use of deictic gestures, and (c) specific deficits in the use of gestures for the communicative purpose of joint attention. Second, high-risk infants showed delays in the acquisition of gestures as evidenced by smaller inventories of communicative gestures and symbolic play acts as well as decreased rates of gesture use.

Findings of delayed and divergent profiles of gesture use in this sample of high-risk 15-month-old infants can inform clinical assessment practices and contribute to the early identification of infants who are at highest risk for developing ASD. Given individual variability of gesture development in typical development and an absence of definitive quantitative information about expected rates of gesture use in the prelinguistic stage of communication, identifying infants with decreased frequency of gesture use may be difficult in a clinical assessment setting. Moreover, decreased gesture rate has been shown to be indicative of broader developmental delay rather than ASD specifically (Clifford & Dissanayake,
Therefore, identifying patterns of gesture use, particularly high proportions of non-directed gestures and specific deficits in deictic gestures and gestures for joint attention, may result in a more specific index of risk for ASD.

In summary, examining gesture profiles (e.g., directed and non-directed gestures, gesture types and functions) as well as rates and inventories of gestures may be the most informative approach for differentiating ASD from other developmental delays in clinical settings. As others have suggested (Luyster, Qui, et al., 2007; Shumway & Wetherby, 2009) results from this study further underscore the importance of including an evaluation of gesture use in infants at risk for ASD using both parent report and direct observation.

**Impact on language development.** Gestures and language are tightly coupled in development (Acredolo & Goodwyn, 1988; Bates et al., 1975; Bates et al., 1979; Bates et al., 1989; Butcher & Goldin-Meadow, 2000; Iverson et al., 1994). Gesture use is predictive of language outcomes in children with typical development (Carpenter et al., 1998; Iverson, Capirci, Volterra, & Goldin-Meadow, 2008; Rowe, Özçalişkan, & Goldin-Meadow, 2008; Thal & Tobias, 1992) as well as children with ASD (Carpenter, Pennington, & Rogers, 2002; Charman et al., 2004; Drew et al., 2007; Luyster, Qui, et al., 2007; Mundy et al., 1990; Sigman & Ruskin, 1999). Moreover, empirical evidence has shown that, similar to typically developing infants, infants with ASD use gestures as a bridge to spoken language (Butcher & Goldin-Meadow, 2000; Fenson et al., 1994). Both initiating and responding to joint attention bids predict language abilities at 24 months (Mundy et al., 2007). Specific impairments in deictic gestures and gesturing for joint attention may forecast language difficulties in this sample of high-risk infants. Although a causal link between increased gesture use resulting in increased in language abilities cannot be established, it remains the case that children with more gestures tend to have better language ability.

Increased gesture use in infants impacts their social and communicative interactions with adults, which in turns allows adults more opportunities to provide
language models in response to infant gestures (Calendra & Wilcox, 2002; Yoder & Warren, 2002). It is likely that adult scaffolding, together with gestural and language models, impact infants’ use of gestures and the development of language. Thus, intervention targeting infant gesture use at the earliest sign of impairment might go a long way toward minimizing the language difficulties predicted by impaired gesture use early in development. However, future research examining the effects of intervention with a specific focus on early gesture use is necessary.

Longitudinal studies have revealed a pattern of findings suggesting a slowing and/or worsening developmental trajectory with respect to social, communication, and play behaviours specific to children with ASD between 14 and 24 months (Landa & Garrett-Mayer, 2006; Landa et al., 2007). Behaviours acquired early in development, particularly social behaviours (e.g., using gaze to modulate social interactions, expression of affect) appear to remain stable over time for infants with developmental delay. Conversely, infants with ASD, although not significantly different from typical infants or those with developmental delay at six months, have been characterized as following a declining trajectory of social, communication, and play behaviours between the first and second year of life (Ozonoff et al., 2010).

**Early intervention.** Identifying infants who are at highest risk for ASD is a critical step toward the goal of initiating appropriate intervention as early as possible. Deficits in gesture use in the current sample of high-risk infants suggest that it may be worthwhile to initiate intervention as early as 15 months of age to minimize further deficits associated with gesture impairments even when a diagnosis of ASD cannot yet be confirmed. Although gestures have been included as targets in interventions reporting positive outcomes for very young children with ASD (e.g., Rogers, et al., 2012), additional research examining the effects of *gesture intervention* on social and language outcomes in infants at risk for ASD is warranted.

Arguably, the interventions most effective for very young children with ASD may be different than those for other types of developmental delays. Research examining interventions targeted specifically at infants and toddlers with ASD is scarce. However, recent studies that have included toddlers (e.g., Early Start Denver Model; Dawson et al., 2010; Pivotal Response Treatment; Bryson, Koegel, et al.,
have shown promising outcomes and thus lend support to impairment-specific intervention. Moreover, effective interventions for older children with this disorder are indeed specific to ASD (for reviews see Rogers, 1998; Bryson, Rogers, & Fombonne, 2003), suggesting that treatments must target core impairments to ensure acquisition of skills in children with ASD. Findings of relatively distinct patterns of gesture use lend support to the argument in favour of impairment-specific intervention. Intervention aimed at addressing the deficits in: (a) the ability to direct gestures to a communicative partner, (b) the use of deictic gestures, and (c) gestures for joint attention may be most appropriate for high-risk infants.

**Overview of Contributions: Mothers**

If high-risk infants show deficits in the acquisition of gestures prior to the onset of spoken words, it is important to determine whether the gestural input they receive during this developmental period is different than that experienced by their low-risk peers. Mothers are often the primary participants in the social interactions within which infants learn all communication, including gestures. Mothers provide scaffolding to support infant learning (e.g., Bruner, 1981; Vygotsky, 1978) and, in turn, infant responses affect maternal behaviours (Bell & Harper, 1977). Although there exists robust literature documenting how mothers of typically developing infants simplify and adjust their communication to accommodate the developmental level of their infants (e.g., motherese, gestures: Goldin-Meadow et al., 2007; Grimminger et al., 2010; Iverson et al., 2006; Iverson et al., 1999; Namy et al., 2000), few studies have examined gestural communication in mothers of children with developmental disabilities. Moreover, there are no known studies that have examined gesture use in mothers of infants at risk for ASD. Therefore, the second aim of the current research was to address limited knowledge in the extant literature about gesture use in mothers of infants at risk for ASD.

The question of whether high- and low-risk infants were exposed to similar gestural input was addressed by comparing gesture use and a number of gesture-related behaviours in mothers of infants at risk for ASD to that of mothers of low-risk infants. Specifically, rates of maternal gesture use (communicative and symbolic play), patterns of gesture types and functions, patterns of how gestures
supplemented language, and maternal prompts for infant gestures were compared. It was predicted that mothers of high-risk infants would show decreased rates and different profiles of gesture use relative to mothers of low-risk infants. However, for the most part, results from this study did not support these hypotheses. Mothers of high-risk infants were also hypothesized to show differences in gesture-related behaviours relative to mothers of low-risk infants. Again, contrary to expectations, mothers were similar in the way they used gesture strategies to supplement their language and in the frequency with which they prompted infant gestures.

It is important to note that the small sample size in this study may have limited statistical power and precluded the detection of group differences in maternal gesture use and the use of gesture-related behaviours. However, the maternal gesture profiles observed in this study were consistent with those found in studies examining gesture use in mothers of typically developing infants. Moreover, evidence from studies examining a number of maternal behaviours related to mother–child interactions also suggests more similarities than differences between mothers of children with ASD and mothers of children who do not have ASD. These studies can be interpreted as providing converging evidence to support the lack of group differences found in this study.

Although null findings can be difficult to interpret, results suggest that mothers of infants at risk for ASD were not providing gestural input that was significantly different than mothers of low-risk infants. A notable exception to this pattern was the finding that the groups of mothers significantly differed in the frequency of symbolic play acts. These findings will be discussed in the context of our current knowledge of maternal gesture behaviour.

**Symbolic play acts.** Mothers of high-risk infants were expected to use symbolic play acts at a lower rate than mothers of low-risk infants. However, results showed that mothers of high-risk infants used symbolic play acts at almost twice the rate of mothers of low-risk infants. Although a number of studies have investigated symbolic play in mothers of infants with typical development (e.g., Namy & Nolan, 2004), the rate of symbolic play in mothers is difficult to extract from reported data. Moreover, there are no known studies that have examined play in mothers of infants.
at risk or children with ASD. Thus, interpreting this finding in the context of the literature was not possible. Results from this study contribute preliminary evidence showing increased rates of symbolic play relative to mothers of low-risk infants.

There are several interpretations of this finding. First, mothers of high-risk infants in this sample may have been uniquely influenced to use more symbolic play acts. Mothers in the high-risk group had at least one older child with ASD and may have received training in intervention strategies for their older child. Moreover, mothers’ experiences with ASD may have included awareness that pretend play is a specific area of weakness in ASD. Mothers may thus have been committed to specifically teaching play skills. Second, mothers of children with ASD have been shown to be more intrusive and directive during interactions with their infants (Cielinski et al., 1995; Marfo, 1992; Roach et al., 1998). If symbolic play activity was perceived as an opportunity for teaching a weak skill, mothers may have been more inclined to model increased rates of symbolic play during the videotaped interaction. Third, results showed that high-risk infants in this sample had decreased rates of symbolic play acts; that is, high-risk infants initiated, responded to, or imitated less of their mothers’ play, which could be interpreted as disinterest in a particular pretend play scheme. This may have resulted in mothers compensating for observed symbolic play difficulties in their infant by using repeated attempts to engage the infant in alternate schemes. On a final note, it is necessary to consider that the mothers were instructed to play with their infants while being videotaped by the investigator, a speech-language pathologist. This context may have induced mothers to try to perform well or to “push” their infants to “perform.” Given the uniqueness of this sample of mothers, results of increased symbolic play acts found in this study would not necessarily generalize to all mothers of infants showing risk for ASD.

**Maternal gesture use.** Mothers did not differ across groups in their overall gesture rates or the profiles of gesture types and functions they used. When examining these profiles, mothers in both groups used primarily deictic gestures, followed by conventional and representational gestures. In terms of gesture functions, mothers in both groups used gestures primarily for joint attention. There
are no known studies that have examined the gesture types and functions used by mothers of infants at risk. However, the profile of gesture types found in this study was consistent with most studies examining gesture types in mothers of typically developing infants (Iverson et al., 1999; O’Neil et al., 2005) and mothers of infants with other developmental delays (i.e., Down syndrome, late-talkers; Grimminger et al., 2010; Iverson et al., 2006). Contrary to findings in the present study, Grimminger et al. (2010) noted that mothers of late talkers used a larger number of deictic and iconic (i.e., representational) gestures than mothers in the comparison group. However, it is important to note that the interaction between mothers and infants in that study was not a natural social interaction. Rather, it involved an instructive task whereby mothers were given a photograph and asked to instruct their child to position objects to match the target in the photograph. Because types of tasks have been shown to influence maternal gestures (Yont, Snow, & Vernon-Feagans, 2003), this instructive task may have inflated the frequency of deictic and iconic gestures. Moreover, the length of the interaction was not well controlled. The interaction was terminated when the child successfully completed the task or when the mother or child had given up. Thus, increased counts of deictic and iconic gestures may have been related to an increased number of attempts by mothers of late-talkers to instruct their infants to complete the task.

Although gestural communication in mothers of infants at risk for ASD has not been examined in the literature, several lines of converging evidence suggest that, relative to mothers of infants with typical development, mothers of infants and preschool children with ASD are similar in a number of aspects related to mother–child interactions. Mothers of infants with ASD have demonstrated similar rates of approach behaviours (Doussard-Roosevelt et al., 2003), similar sensitivity (Baker et al., 2010), similar levels of child-directed language (Venutti et al., 2012) and similar caregiver–child synchrony (Siller & Sigman, 2002). The difference most commonly identified in the literature is that mothers of infants (Wan et al, 2012) and preschool-aged children with ASD (Doussard-Roosevelt et al., 2003; Lemanek et al., 1993) are more intrusive/directive compared with other mothers. These studies
lend support to the possibility that mothers of infants at risk for ASD are not different in terms of gestural communication with their infants.

Although the similarities between the two groups of mothers in this study are consistent with literature examining other aspects of mother–infant interaction in other studies, it would be premature to conclude that mothers of high-risk infants demonstrate no differences in the use of communicative gestures and gesture-related behaviour based on this research. It remains possible that mothers of infants at risk may demonstrate more subtle differences in their gesture use that were not detected because of limited statistical power.

**Gesture-related behaviours.**

**Gesture strategies.** Mothers of high-risk infants did not differ from mothers of low-risk infants with respect to the profile of gesture strategies used to supplement their language. Mothers in both groups used gesture strategies primarily to emphasize their verbal utterances, which occurred almost four times as often as gestures used to disambiguate utterances. Gestures used to add semantic information to utterances were used least often. The use of gesture strategies has not been examined to date in mothers of infants at risk for ASD. However, this profile was consistent with studies examining gesture strategies in mothers of typically developing infants (Iverson et al., 1999) and mothers of children with other developmental delays (i.e., Down Syndrome, late talkers; Grimminger et al., 2010; Iverson et al., 2006). Notably, despite similar profiles of strategies, Iverson et al. (1999) and Grimminger et al. (2010) both showed that mothers of infants with delayed development held their gestures longer (i.e., throughout their verbal utterance) than mothers in the control groups. Thus, compared to mothers of typical infants, mothers of infants with delayed development showed qualitative differences in their use of gesture strategies.

**Maternal prompts.** Mothers of high-risk infants in this study also used similar prompt rates to encourage infant gesture use. To date, only one other study has examined maternal prompts for infant gestures (Colgan et al., 2006). Unfortunately, the authors did not compare groups of mothers with respect to rate or profile (i.e., model, verbal and physical) of maternal prompts. Thus, the similar
rates of prompting between the two groups of mothers in this study cannot be corroborated.

The initial intent of this study was to examine three types of prompts (i.e., model, verbal, and physical) but small counts prohibited group comparisons of prompting profiles. However, during videotaping, mothers of high-risk infants were observed to physically prompt infants to *touch point* (i.e., index finger making physical contact with the referent). Therefore, a post-hoc examination was conducted that revealed qualitative differences in the physical prompts used in both groups of mothers. For example, while some mothers in both groups used physical prompts (6/8 mothers in the high-risk group and 6/9 in the low-risk group), only mothers of high-risk infants physically prompted deictic gestures (e.g., touch point). Mothers of low-risk infants used physical prompts primarily for representational gestures in songs (i.e., hands to eyes for crying baby). Thus, while overall prompting rates were not different, only mothers of high-risk infants physically prompted for infants’ deictic gestures suggesting a qualitative difference between groups of mothers.

Notwithstanding the similarities in rates and profiles of gesture-related behaviours found among the groups of mothers in this study, qualitative differences may still exist. Qualitative aspects of the gesture-related behaviours were not specifically examined in this study. However, as discussed above, qualitative differences have been documented in a number of studies examining the communication and interaction behaviours of mothers of infants with developmental delays and those at risk for ASD. It is thus possible that qualitative differences in gesture-related behaviour may exist in mothers of infants at risk for ASD. Furthermore, given the small number of participants in this study, it cannot be definitively concluded that mothers of infants at risk for ASD are not different in gesture-related behaviours relative to mothers of infants with typical development. Group differences in the frequency or profile of gestures and related behaviours might have come to light with a larger sample size.

**Maternal responses to directed and non-directed infant gestures.** Following the finding of high rates of non-directed gesture use in the group of
infants at risk for ASD, a post-hoc question was formulated. Based on the notion that non-directed gestures would be more likely to be interpreted as non-intentional, mothers of high-risk infants were predicted to respond less often to infant gestures that were not directed. However, this hypothesis was not supported by the data. Mothers of high-risk infants responded equally to their infants’ gestures regardless of whether the gesture was directed or not.

In interpreting this finding, it is important to keep in mind that as part of their participation in the larger, longitudinal study, mothers attended a 12-month clinic visit during which they were given feedback that their infants were showing signs of ASD. Thereafter, when infants reached 15 months of age, mothers were videotaped interacting with their infant for this study. Thus, one possible interpretation of this finding is that in an effort to increase infant social communication, mothers were committed to responding to all communicative attempts made by their infants. Unfortunately, this compensation may result in reinforcing gestures that are not conventionally communicative. As infants acquire additional communication partners, non-directed gestures may not elicit consistent responses. Inconsistent responses to non-directed infant gestures may negatively impact the development of gestural communication in these high-risk infants.

**Understanding why mothers of high-risk infants with ASD are not different from mothers of low-risk infants.** In light of the largely similar findings with respect to mothers’ use of gestures and gesture-related strategies, it becomes important to understand why the mothers of infants at risk for ASD did not differ from mothers of low-risk infants with respect to gestures and gesture behaviours. Three considerations influenced the predictions of differences in maternal use of gestures and gesture-related behaviours. The first was the possibility that mothers of infants at risk for ASD had an increased likelihood of having social communication characteristics associated with broader autism phenotype (BAP; Constantino & Todd, 2000; 2005). These characteristics would be expected to influence maternal gesture use. However, there were no mothers who met criteria for broader autism phenotype.
The second consideration that influenced hypotheses regarding mothers was the increased possibility of mothers of infants in the high-risk group having clinical depression. Having a child with ASD may increase symptoms of maternal depression, which has been shown to negatively impact mother–child interactions (Murray & Cooper, 2003; Murray et al., 1996b). The presence of clinical depression could be expected to decrease the frequency of maternal gestures and play. It is important to note that although mothers of high-risk infants reported more symptoms of depression (e.g., fatigue), only one mother reported enough symptoms to fall into the mild range of clinical depression warranting referral for mental health support. Follow-up with this mother revealed that several recent family health-related issues as well as the placement of a service dog for another family member had increased her level of stress temporarily at the time coinciding with the administration of the self-report depression inventory.

A third consideration that influenced predictions about maternal gesture behaviours was based on psychosocial theories proposing that infant behaviour affects maternal behaviour and vice versa (e.g., Bruner, 1981; Vygotsky, 1978). Therefore, it was reasonable to expect that high-risk infants may participate less in communicative and play interactions, which was, in turn, predicted to negatively impact the frequency of maternal communication and mothers’ play with their infants. However, data did not support these hypotheses.

One could argue that, for mothers of infants at risk for ASD, it would have been reasonable to predict a higher frequency of communicative gestures and related behaviours due to their increased concern about their infants’ development. Although group differences were not found in terms of frequency, mothers of high-risk infants had two findings that could be interpreted as lending support to the notion that mothers of high-risk infants had heightened concern about their infants’ development. First, increased frequency of maternal symbolic play acts could be interpreted as mothers working harder to encourage their infants to play. Second, mothers appeared to respond to all infant gestures, even those that were not directed. As discussed above, this may reflect an understanding of the importance of infant communication. In other words, already having one child with ASD may have
heightened mothers’ awareness of their infants’ communication to the extent that they responded to all gestures. Similarly, a heightened awareness of the importance of play may have motivated mothers to model symbolic play.

The null findings with respect to maternal gesture rates, profiles of types and functions, and other gesture related behaviours prohibit the conclusion that mothers of high-risk infants are not different with respect to gesturing than mothers of low-risk infants. It is possible that mothers of infants at risk for ASD have quantitative and/or qualitative differences in rates and profiles of gesture use and gesture-related behaviours that were not detectable given the small sample size of this study. Alternatively, results from this research, taken together with findings from other studies showing similar communicative and social behaviours in mothers of children with ASD, lend support to the notion that mothers of high-risk infants provide similar gestural input to their infants to other mothers. That being the case, the gesture deficits apparent in infants by 15 months of age are likely unrelated to differences in maternal gesture use.

**Implications of Findings for Mothers**

If mothers of infants at risk for ASD are not different in their gesture behaviours than mothers of infants not at risk, this has possible implications for intervention research. It is possible that aspects of maternal gesture use could be manipulated in intervention research in order to determine whether changes in maternal gestural behaviours might effect change in infants’ gestures.

Mothers (and fathers) are arguably the primary communication partners for infants in the first two years of life and may thus be the best agents of change. Parent-mediated interventions have demonstrated that parents are able to learn and successfully use novel intervention strategies (Bryson, Koegel, et al., 2007; Dawson et al., 2010; Rogers et al., 2012; Coolican, Smith, & Bryson, 2010). Furthermore, parent-mediated interventions that include targeting gestures have shown promising outcomes for children with ASD under the age of two (Rogers et al., 2012). However, further research is warranted to examine whether mothers of infants at risk for ASD trained to focus on gestures can impact gesture use in these infants.
Integrated Implications of Findings for Mothers and Infants

With the exception of mothers’ responses to their infants’ non-directed gestures, this dissertation did not examine maternal responses to infant gestures or infant responses to maternal gestures. However, when patterns of maternal gestures are examined alongside patterns of infants’ gestures, a disparate picture emerges. Mothers, on the one hand, used primarily deictic gestures (i.e., significantly more than conventional and representational gestures) and gestured most often for joint attention purposes (i.e., significantly more often than for behaviour regulation and social interaction). Infants, on the other hand, showed primary deficits in deictic gestures and gestures used for joint attention purposes despite being exposed to gestural input that was similar to that received by typically developing infants.

In line with the theoretical interpretation that high-risk infants have difficulty coordinating modes of communication because of the decoupling of developmental systems, dynamic systems theory may also apply in infants’ responses to maternal gestures. Mothers in both groups used gestures to supplement their spoken language; that is, mothers spoke and gestured at the same time, thus requiring their infants to process language and gestural input simultaneously. Especially in the case of maternal deictic gestures, infants would also need to shift their visual attention between their mother and an object referent. This multimodal input may not be helpful for infants at risk for ASD. That is, infants who have difficulty with coordinating attention and communication between people and objects may not benefit from maternal gesture models in a similar way typically developing infants do. They may, in effect, be “missing” the gesture models of parents due to deficits in shifting attention.

Limitations and Future Research Directions

In addition to the limitations previously cited, two pertinent limitations and future research directions remain to be discussed. This study did not include a comparison group of infants with developmental delay. Moreover, longitudinal data with respect to gesture profiles in this sample of infants were not collected. While studies of slightly older children corroborated findings of divergent gesture patterns with respect to gesture types and functions, non-directed gesture use has not been
explored. Therefore, whether increased non-directed gesture use signals vulnerability in ASD or whether it is indicative of general developmental delay is not conclusive. Prospectively, recruiting samples of infants at increased risk for developmental delay may prove difficult. However, given the increased risk of language delay in populations at risk for ASD, prospective studies may offer a unique opportunity to compare this aspect of early gesture use in infants who go on to have ASD and those who continue with language delay alone.

In addition, this study’s small sample size limited exploration of relationships between maternal gesture use and infant gesture use. Moreover, gesture use in mothers and infants was not examined with respect to initiating versus responding. Future research examining infant responses to maternal gestures and maternal responses to infant gesturing may contribute to a better understanding of the link between parental input and infant gesture learning. To determine whether intervention in gestural communication impacts infant gesture use, language abilities, and more fundamentally, success in early social interactions, would be an important goal for future research.

Conclusions

By 15 months of age, infants at risk for ASD demonstrate delays and, perhaps more importantly, different patterns of gestures types and functions relative to infants at low risk for ASD that are consistent with those patterns described in preschool and school-aged children with ASD. These patterns of deficit are robust in that they were evident in a clinical assessment as well as in a more natural interaction with mothers. Patterns of gesture use, in particular a high proportion of gestures that are not communicatively directed to a partner, could be considered as early red flags for ASD by clinicians. Although the majority of this sample went on to receive a clinical diagnosis of ASD, results emphasize the importance of including an evaluation of gestures with at-risk populations and suggest the need to investigate gesture-based interventions. Impairment-specific intervention to address the gesture deficits that have been identified may impact developmental trajectories for infants at risk for ASD.
Gesture behaviours in mothers of infants at risk do not appear to be fundamentally different from those of mothers whose infants are not at risk for ASD. Despite relatively similar exposure to maternal gesture usage, high-risk infants showed reduced and relatively distinct patterns of gesture use. It is thus doubtful that maternal input underlies the gesture differences seen in infants. However, mothers of infants at risk may have an important role in facilitating their infants’ acquisition of gestures. Evidence from parent-mediated intervention studies demonstrates that maternal input has been shown to impact the acquisition of social and communication skills in infants. Thus, a focus on gesture use for infants with ASD has important implications for understanding and recognizing early signs of ASD and potentially for initiating the earliest possible intervention, ideally even before diagnosis is certain.
References


Appendix A

Orientation to Study and Instructions for Mothers

1. Review of the general purpose of the study and general instructions.

“This study is designed to evaluate communication between infants and their mothers. Please do not worry about how your baby is behaving during the activities. If your baby does not seem to be interested in an activity, please feel free to go on to the next activity. Each activity will last for about 2 minutes. I will let you know when the time is up and give you the next activity. I will give you the instructions before each activity. Have fun with your baby!”

2. Activities and Instructions.

a) Highchair Activities Instructions

• Song (Itsy Bitsy Spider): “Sing the song with your baby as you normally would.
• Book (“Pat the Bunny”): “Your baby will be seated in the highchair. Share the book with your baby as you normally would.”
• “Surprise Box” (wind-up toy in a clear container): “Let your baby explore this toy and interact with your baby as you normally would.”

b) Floor Activities Instructions

• Social Game (Horsie Game) “Play this game with your baby as you normally would.”
• Novel Toy (Baby Bird): “Let your baby explore this toy and interact with your baby as you normally would. Let your baby know when the toy is finished.”
• Play Toy Set: “Play with these toys with your baby as you normally would. Let your baby know when the toys are finished.”
Appendix B

Infants Siblings at Risk for Autism Spectrum Disorder: Home Visit
Caregiver Perception Rating Form

Child I.D.: __________________ Filled out by: __________________
Date of Birth: _______________ Date of Home Visit: _______________

Instructions: Please compare your child's behaviour during this play interaction to your observations of your child during typical play interactions. Circle the response that comes closest to your observations.

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<td></td>
<td>less than usual/sleepy</td>
<td>typical</td>
<td>greater than usual</td>
<td>more negative than usual</td>
<td>typical</td>
<td>more positive than usual</td>
<td>less interest than usual</td>
</tr>
</tbody>
</table>

Comments:

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
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Appendix C

CSBS DP Behavior Sample: Caregiver Perception Rating

<table>
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<th>Child’s name:</th>
<th>Date of birth:</th>
<th>Date filled out:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filled out by:</td>
<td>Relationship to child:</td>
<td></td>
</tr>
</tbody>
</table>

Instructions for caregivers: Please compare your child’s behavior during the communication and play assessments we have just completed to your observations of your child in similar situations. Circle the response that comes closest to your observations.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
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</thead>
<tbody>
<tr>
<td>1. Alertness</td>
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<td>very alert/greater than usual</td>
</tr>
<tr>
<td>2. Emotional reaction</td>
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<td>typical</td>
<td>more positive than usual</td>
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<tr>
<td>3. Level of interest and attention</td>
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</tr>
<tr>
<td>4. Comfort level</td>
<td>more cautious/more wary than usual</td>
<td>typical</td>
<td>more comfortable/relaxed than usual</td>
</tr>
<tr>
<td>5. Level of activity</td>
<td>less active than usual</td>
<td>typical</td>
<td>more active than usual</td>
</tr>
<tr>
<td>6. Overall level of communication</td>
<td>less than usual</td>
<td>typical</td>
<td>greater than usual</td>
</tr>
<tr>
<td>7. Play behavior</td>
<td>less organized and less focused</td>
<td>typical</td>
<td>more organized and focused</td>
</tr>
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Comments:

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Communication and Symbolic Behavior Scales Developmental Profile by Amy M. Wetherby & Barry M. Prizant
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Appendix D

Telephone Script for Contacting Mothers Scoring Seventeen or Higher on the BDI-II

Hello Ms. ____________,

My name is Shelley Mitchell. I am the speech-language pathologist/Ph.D. student who is conducting the study about infant–mother communication. As part of that study you recently filled out a questionnaire that evaluates symptoms of depression. Some of the answers that you gave on that questionnaire suggest that you may have enough symptoms of depression to warrant some support or further evaluation. I am calling to encourage you to contact your family doctor for further evaluation of how you are feeling and address any medical causes for any of these feelings/symptoms. Is there anything I can do to help you connect with your family doctor?
Appendix E

Gesture Coding Manual: Infants

Guidelines for Coding Infant Gestures

The following guidelines will be used to determine the number of gestures to be coded:

• If a gesture is held while an accompanying vocalization or word changes as if to clarify communication or repair a communication breakdown two gestures will be coded. For example, if an infant reaches for a toy and vocalizes then turns to and adult and vocalizes again while holding the reach this will be coded as two gestures.

• If a vocalization is held and the gesture is distinctly repeated or changed to indicate a repair of communication breakdown (e.g., lack of response from the communicative partner), two gestures will be coded.

• If the gesture is produced repeatedly (e.g., touch point – touch point or bounce body – bounce body) to emphasize, this will be coded as a single, directed gesture.

• If two gestures are produced simultaneously, both gestures will be coded.

• Hitting is not coded as a gesture.

• Directedness is coded for all gestures separately. Gestures that are coded as Non-Directed will not be coded for communicative function.

Gesture Codes

Types of gestures

Deictic Gesture [D]. A deictic gesture signals a specific referent (i.e., differentiating it from other referents) that is in physical space occupied by both persons. One person attempts to shift the attentional focus of another person to the referent. The referent then becomes the focus of the attention or experience of both persons. The referent’s meaning is given entirely by the context of the interaction – not by the gesture itself. Deictic gestures include:

1. Point.
   • Point with index finger extended (distal or proximal).
   • Point with an Object in hand.
   • Touch Point is coded when index finger touches the referent.
• Touch and Tap is coded when index finger touches the referent – lifts off the referent and immediately touches referent again to emphasize. Touch and tap is coded as a repeated gesture and therefore gets credit for directedness.
• Touch with Motion is coded when index finger touches the referent and moves but remains in contact with the referent (e.g., infant touches picture and circles finger around the picture while keeping index finger in contact with the page). Touch with motion is coded as a single gesture.
• Whole Hand Touch is coded when a whole hand touches or touches and taps a referent.

2. Show.
• Show is coded when an object is held up and oriented toward a person.
• Show and Shake is coded when an object is held up, oriented toward a person while shaking the object.
• Show then Give is coded when an object is held up and then given to another person. This is counted as one gesture and coded as a Give.

3. Reach
• Reach is coded when a person is reaching with one or both arms extended toward an object that is out of reach or that someone is holding.
  o Reaching for bubbles in the air is not coded as Reach.
  o Reaching for the bubble jar or bubble wand to obtain the wand is coded as Reach.
  o Reaching for the bubble wand to pop a bubble that is on the wand is not coded as Reach
• Reach to Take is coded when one person is holding or offering an object and another person reaches toward the object and takes it.
  o Reaching for balloon to squeeze the air out is not coded as Reach to Take.
• Partial Reach is coded when a person is reaching toward an object that is out of reach with one or both arms partially extended.
• Reach with Open Hand(s) or opening and closing hand(s) is coded when a person is reaching toward an object that is out of reach with one or both arms extended and hand(s) is opening and closing. Reaching arm(s) out to mother for
comfort will be coded as a Conventional gesture (and Social Interaction) not a Deictic gesture because the meaning of the gesture is inherent in the gesture and no objects are referred to as in the case of a Deictic gesture.

4. Give
- Give an object to another person by placing it in his/her hand.
- Give gestures are all coded as Directed by definition.
- Offer an Object is coded when an object is held out in front of a person for acceptance or rejection of the object. For example, if an infant holds a toy out toward his/her mother as an invitation to join in the play activity.
- Show then Give is counted once as a Give.

*Conventional Gesture [C].* Conventional gestures indicate semantic content with no specific object represented. Their form and meaning can be culturally defined (Move Index Finger Side to Side for “no, no, no”) or less culturally defined (Nod or Shake the Head for “yes,” and “no”) or can be identified in the context of caregiver–child interactions (e.g., Wave Hello/Good-bye, Arms Out to indicate “all gone,” Blow a Kiss, Clap, Finger to Mouth for “shhh,” Wave Hands for “too hot,” Shoulders Raised for “Where did it go?” or “I don’t know,” Clasp Hands Together in delight or pride, Arms Raised to indicate “Pick me up.” Conventional gestures include:

1. Emotive gestures
   - Dance in presence of music, singing, or a person
   - Bounce Body up and down to continue “Horsie Game” or to indicate excitement or anticipation.
   - Bang Hands on the table as an exclamatory comment to indicate anticipation or excitement of an object coming soon, to show excitement, to show frustration, to draw attention to him/herself.
   - Bangs objects on table for the purpose of exploring the object will not be coded.

2. Push Away
   - Pushing (person’s) hand or face away to indicate protest
   - Flailing Hands to push objects away
   - Push Objects toward a person
• Push/Drop an Object on the floor.
3. Pull an Object/Person (e.g., leading by the hand for “come”).
4. Peek-a-boo with hands or with facecloth/blanket.
5. Touch a person to gain their attention.

**Representational Gesture [R]**. A representational gesture refers to objects, persons, or events and represents attributes or actions performed with or by their referents. The gesture itself captures aspects of the referent and is therefore not dependent on the context in which the gesture is produced. Representational gestures include:

1. Symbolic gestures: enactive movements without an object indicating object recognition (e.g., Arms Out for “big or “airplane”, Point for “up,” Index Finger Moved in Circles for “spin,” Arms Flap for “bird,” Sniff for “smell the flowers”, “Blow” with lips, Lip Smack for “eating” or “yummy”, Claw Hand to represent “tiger,” Scratch Armpits to represent “monkey”).
2. All gestures produced during the song (e.g., “Rain Hands” to represent falling rain in the Itsy Bitsy Spider song)
3. American Sign Language and Baby Signs (e.g., “O-shaped” Hands coming to midline for “more,” Open Hands Sweeping Together for “all done”; Shumway & Wetherby, 2009).

**Directedness**

**Directed [d+]**. Evidence that the gesture was directed toward a person includes:

1. Give an object to a person.
2. Move an object toward a person (throw an object in the direction of a person is not enough evidence of directedness).
3. Gesture is produced while looking at a person. However, if an infant gestures to the mother but eye gaze is directed toward the examiner, the infant would not be credited for a directed gesture.
4. Gesture is produced while vocalizing or verbalizing (giggling is not counted as a vocalization or verbalization).
5. Gesture is produced while touching a person.
6. Gesture is produced immediately in response to person’s previous statement or action. Evidence that a gesture has been produced in response to a person’s previous statement or action includes:
   • Person offers object or action and infant immediately uses a gesture to take or refuse the object or action. For example:
     o Mother offers hand saying “Want help?” and the infant immediately gives the object that he/she needs help with.
     o Mother offers to pick up the infant by saying “Want up” and infant immediately raised arms up to indicate wanting to be picked up.
   • Person directs the infant to do something and the infant immediately uses a gesture to respond to the directive (can be positive or negative). For example:
     o Mother says, “You do ‘Itsy Bitsy spider,’ and the infant makes Spider Hands for “Itsy Bitsy spider.”
7. Gesture is imitated immediately or within one turn of the mother.

**Non-Directed [d-].** Non-Directed gestures are those coded as deictic, representational or conventional that did not meet the coding criteria above for Directed. Non-directed gestures will not be coded for communicative function.

**Functions of Gestures.**

*Behaviour Regulation [BR].* Gestures used for Behaviour Regulation are those used to regulate the behaviour of another person to request or protest an object or action.

1. Request objects: gestures used to demand a desired object.

2. Request action: gestures used to command another person to carry out an action (“Do it for me”).

3. Protest: gestures used to refuse an undesired object or to command another to cease an undesired action.

• Gestures produced by infants in response to adult initiations will be coded as Behaviour Regulation only if the child indicates that they desire an object or action or are refusing an object or action suggested by the adult (i.e., if adult gives or offers an object, or offers a choice of objects or choice of actions and child responds with a gesture). Adult initiatives can be verbal, gestural, or both. Examples include: (a)

- If the toy is offered or given because the infant explicitly wants the adult to do something with the toy (e.g., the infant gives a spoon to the mother and wants her to feed herself).

**Social Interaction [SI].** Gestures used for Social Interaction those used to draw another’s attention to him or herself.

1. Request social routine: gestures used to command another person to commence or continue carrying out a game-like social routine or mark the end of a social routine (Do it with me).
   - Clap at the end of the song or other activity will be coded as Social Interaction because the implied function of the clapping is to mark the end of a social routine (e.g., “The song is finished”).

2. Show off: gestures used to attract another person’s attention to oneself.
   - Bang of hands on table to draw attention to him/herself.

3. Greet: gestures used to indicate notice of another’s presence, or to signal the initiation or termination of an interaction.

4. Call: gestures used to gain the attention of another person, usually to indicate that a communicative act is to follow.
   - Tap a Person with index finger or whole hand or whole hand while holding an object will be coded as Social Interaction because the primary purpose of the gesture is to obtain the attention of the communicative partner.

5. Acknowledge a Person: gestures used to indicate awareness of another person’s previous statement or action; involves the infants’ focusing attention on or shifting attention to the communicative partner. This includes spontaneous imitation of a gesture produced by the communication partner (that is clearly not for Behaviour Regulation or Joint Attention). Examples include:
• Mother Smacks Lips and then the infant Smacks Lips spontaneously, mother Claps Hands and infant Claps Hands in response).
• Gestures produced following a verbal prompt (e.g., mother says “Say bye-bye” and the infant waves). However, gestures produced in response to answering a question are not coded as Social Interaction (e.g., mother asks “Where is the bunny?” and the infant points to the bunny).
• Gestures produced by infants in response to an adult directive that function solely to acknowledge the adult’s directive or comment will be coded as Social Interaction. Adult directives can be verbal, gestural, or both. These gestural responses by the infant are not in response to an adult directing the infant’s attention to an object and they are not gestural responses that indicate the infant desires an action or event. Examples include:
  o The adult directs the infant to “Say please” and the infant gestures or signs “please.”
  o The adult suggests or directs the infant to carry out or repeat a social routine and the infant responds with a gesture.
  o If the adult makes a comment (e.g. “That’s like your bunny”) and the infant acknowledges the adults’ comment by responding with a gesture.

6. Request permission: gestures used to seek another’s consent to carry out an action; involves the infant carrying out or wanting to carry out the action.
7. Request comfort: gestures used to seek reassurance or comfort. Examples include:
• Infant reaches for mother (or other adult) with one hand/arm or both hands/arms. when scared, tired, or bored.

**Joint Attention [JA]**. Gestures used for Joint attention are those used to direct another’s attention to an object or event or to get the other person to look at or notice something of interest.
1. Comment: gestures used to direct another person’s attention to an entity or event. Examples include:
• Emotive gestures to show anticipation of a wanted object or action or excitement, such as clapping, banging on table with hands, will be coded as Joint Attention because the communicative intent is an exclamatory comment to share excitement.
• Infant offers or gives a toy to an adult as an invitation into play.
• Clap/Clasp of hands for enjoyment or pride in accomplishment.
• Bang Hands on table will be coded as Joint Attention if the gesture is produced as an exclamatory comment to indicate anticipation or excitement about an object coming soon.

2. Request information: gestures used to seek information, explanations, or clarifications about an entity, event, or previous utterance.
• Gestures produced in response to a request for information will be coded as Joint Attention. For example, if the mother asks “Is he eating his supper?” and the infant nods, this will be coded as Joint Attention because the mother is directing the infant’s attention to a specific topic. Similarly, if the mother asks, “Where is Elmo’s nose?” and the infant points, this will be coded as Joint Attention.
• Gestures produced by infants in response to an adult directive requiring the infant to attend to an object or event will be coded as Joint Attention. Adult directives can be verbal, gestural, or both. Examples include:
  o An adult says: “Give ___ to me,” “Can I have one?,” “My turn (with a toy),” “Put it here,” “Show me___,” “Where is___?,” “Time to clean up,” “What’s inside?”, “Find the ___” and the infant responds with a gesture.

3. Clarification: gestures used to clarify the infant’s previous gesture; may be unsolicited or solicited by the communicative partner. For example, if an adult asks “Where do you want to put it?” and the infant points to a location.

   **Symbolic Play Act [SPA].** A Symbolic Play Acts is an appropriate actions performed with a toy either independently or toward an agent (self, mother, clinician, baby doll, Elmo). When two Symbolic Play Acts are performed, two separate Symbolic Play Acts will be coded. For example, scoop and feed is coded as two Symbolic Play Acts. Examples include:
• Pour, feed, eat, brush, drink with cup or bottle, stir, “cheers” (with cups or bottles), rock baby doll, or Elmo.
• Hug/kiss baby doll or Elmo; however hug/kiss mother or clinician will not be coded.
• Put lid on the frying pan will be coded; however, taking the lid off the frying pan will not be coded because this behaviour cannot be differentiated from simply picking up the lid.
• Bang an object for the purpose of animating the toy (e.g., making the frog jump).
Appendix F

Gesture Coding Manual: Mothers

Guidelines for Coding Mothers’ Gestures

The following guidelines will be used to determine maternal gestures and gesture-related behaviours to be coded:

• Maternal gestures directed to the clinician or other individuals in the home will not be coded.

• Language directed to the examiner will not be transcribed or coded as a Gesture Strategy to augment spoken language (e.g., Emphasize, Disambiguate, or Add).

• If two gestures are produced simultaneously, both gestures will be coded.

• If the mother produces a gesture and maintains the gesture while repeating or changing the language that she uses with that gesture, the held gesture will be coded as two gestures only if the code for the Gesture Strategy changes. Examples include:
  o The mother Points to a toy and says “get that one” to Disambiguate then continues to hold the Point and says “there” to Disambiguate, the Point will be coded as a single gesture; however, if a gesture is repeated following a short pause, however, each gesture would be coded even if the Gesture Strategy code does not change.
  o The mother picks up the book to Show the infant the Show will be counted as one gesture; continued showing the book is not counted unless the mother repeats language or changes language while maintaining the gesture. Each change or repetition will be coded as a Show and coded for Gesture Strategy.
  o If the mother is showing the book and then Touch Points or Points to a picture this will be coded as a separate gesture.

Gesture Codes

Types of Gestures

Deictic Gesture. A Deictic gesture signals a specific referent (i.e. differentiating it from other referents) that is in the physical space occupied by both persons. One person attempts to shift the attentional focus of another person to the referent. The referent then becomes the focus of the attention or experience of both
The referent’s meaning is given entirely by the context of the interaction—not by the gesture itself. Deictic gestures include:

1. **Point.**
   - Point with index finger extended (distal or proximal).
   - Point with Object in hand.
   - Touch Point is coded when index finger touches the referent.
   - Touch and Tap is coded when index finger touches the referent—lifts off the referent and immediately touches referent again to emphasize. Touch and Tap is coded as a repeated gesture and therefore gets credit for directedness.
   - Touch with Motion is coded when index finger touches the referent and moves but remains in contact with the referent (e.g., mother touches picture of boy in the book and moves finger to the picture of girl while keeping index finger in contact with the page).
   - Whole Hand Touch is coded when a whole hand touches or touches and taps a referent.

2. **Show.**
   - Show is coded when an object is held up and oriented toward a person; however, holding an object up in order to help the infant perform an action on the object is not coded.
   - Show and Shake is coded when an object is help up, oriented toward a person while shaking the object.
   - Show then Give is coded when an object is held up and then given to another person. This is counted as one gesture and coded as a Give.
   - Show Action is coded when an object is held up and oriented toward a person and there is evidence that the action of the object is being shown or demonstrated. Examples include:
     - The mother Shows a wind-up toy, pauses and marks the action paring each turn of the toy with “One, two, three” or “Ready, set go”.
     - The mother labels the action that is being demonstrated (e.g., the mother is winding the wind-up toy and says “Turn, turn, turn”).
The mother uses language that directs attention to the action (e.g., the mother holds the baby duck and feeds it saying “Look, the duck is drinking milk”).

3. Reach
   • Reach is coded when a person is reaching with one or both arms extended toward an object that is out of reach or that someone is holding.
   • Reach with Open Hand(s) or Palm Up is coded when a person is reaching toward an object that is out of reach with one or both arms extended and hand(s) is open or palm is facing up.

4. Give
   • Give an object to another person by placing it in his/her hand.
   • Offer an Object is coded when an object is held out in front of a person for acceptance or rejection of the object. For example, if mother is offering a toy and suggesting an action that she wants the infant to carry out (e.g., “Baby’s hungry!”) this is coded as a Deictic gesture. Holding a toy to help the infant carry out an action is not coded as a gesture.

   **Conventional Gestures [C]**. Conventional gestures indicate semantic content with no specific object represented. Their form and meaning can be culturally defined (Move Index Finger Side to Side for “no, no, no”) or less culturally defined (Nod or Shake the Head for “yes,” and “no”) or can be identified in the context of caregiver–child interactions (e.g., Wave Hello/Good-bye, Arms Out to indicate “all gone,” Blow a Kiss, Clap, Finger to Mouth for “shhh,” Wave Hands for “too hot,” Shoulders Raised for “Where did it go?” or “I don’t know,” Clasp Hands Together in delight or pride. Conventional gestures include:
   1. Emphatic gestures.
      • Whole hand with palm open to emphasize a word.
   2. Peek-a-boo with hands or with facecloth/blanket.
   3. Touching a person to gain their attention.
   4. Emotive gestures.

   **Representational Gesture [R]**. A representational gesture refers to objects, persons, or events and represents attributes or actions performed with or by their
referents. The gesture itself captures aspects of the referent and is therefore not dependent on the context in which the gesture is produced. Representational gestures include:

1. Symbolic gestures: enactive movements without an object in hand indicating object recognition (e.g., Arms Out for “big or “airplane”, Point for “up,” Index Finger Moved in Circles for “spin,” Arms Flap for “bird,” Sniff for “smell the flowers”, “Blow” with lips, Lip Smack for “eating” or “yummy”, Claw Hand to represent “tiger,” Scratch Armpits to represent “monkey”).

2. All gestures produced during the song (e.g., “Rain Hands” to represent falling rain in the Itsy Bitsy Spider song)

3. American Sign Language and Baby Signs (e.g., “O-shaped” Hands coming to midline for “more,” Open Hands Sweeping Together for “all done”; Shumway & Wetherby, 2009).

**Function.**

**Behaviour Regulation [BR].** Gestures used for Behaviour Regulation are those used to regulate the behaviour of another person to request or protest an object or action.

1. Request objects: gestures used to demand a desired object.

2. Request action: gestures used to command another person to carry out an action.
   - When a mother offers an object or action (e.g., “Should we open it?” or “Do you want to feed the baby?,” this will be coded Behaviour Regulation because the implication in the offer is directive/illocutionary.
   - When a mother offers or shows and object and comments (e.g., “The baby’s hungry”) this will be coded Behaviour Regulation because the implication in the offer/show is directive/illocutionary.

3. Protest: gestures used to refuse an undesired object or to command another to cease an undesired action.

**Social Interaction [SI].** Gestures used for Social Interaction those used to draw another’s attention to him or herself.
1. Request social routine: gestures used to command another person to commence or continue carrying out a game-like social routine or mark the end of a social routine (Do it with me).

- Clap at the end of the song or other activity will be coded as Social Interaction because the implied function of the clapping is to mark the end of a social routine (e.g., “The song is finished”).

- Gestures produced in the song activity will be coded as follows:
  - Itsy Bitsy Spider—each gesture for “spider,” “rain,” “washed out,” or “sun” will be coded as one gesture.
  - Wheels on the Bus—each “round and round” will be coded, giving one verse of this song a total of three gestures.

2. Show off: gestures used to attract another person’s attention to oneself.

3. Greet: gestures used to indicate notice of another’s presence, or to signal the initiation or termination of an interaction.

4. Call: gestures used to gain the attention of another person, usually to indicate that a communicative act is to follow.

- Tap a Person with index finger or whole hand while holding an object will be coded as Social Interaction because the primary purpose of the gesture is to obtain the attention of the communicative partner.

- Clap, Tap the table tray of the highchair, Tap or Pull on the infant’s hand or body will be coded as Social Interaction because the primary purpose of the gesture is to obtain the attention of the communicative partner.

5. Acknowledge a Person: gestures used to indicate awareness of another person’s previous statement or action; involves the infants’ focusing attention on or shifting attention to the communicative partner. This includes spontaneous imitation of a gesture produced by the communication partner (that is clearly not for Behaviour Regulation or Joint Attention). Examples include:

- Infant Smacks Lips spontaneously and then mother Smacks Lips in response.

6. Request permission: gestures used to seek another’s consent to carry out an action.
Joint Attention [JA]. Gestures used for Joint attention are those used to direct another's attention to an object or event or to get the other person to look at or notice something of interest.

1. Comment: gestures used to direct another person’s attention to an entity or event. Examples include:
   • Gestures used to shift the attention of the infant to an action or a toy.
   • Mother gives the infant an object to invite him or her into the play without a directive (e.g., “Here is spoon for you”).

2. Request information: gestures used to seek information, explanations, or clarifications about an entity, event or previous utterance. For example, an infant produces Arms Out for “Where?” and the mother responds with a Point to indicate “There!”.

3. Clarification: gestures used to clarify a previous gesture; may be unsolicited or solicited by the communicative partner. For example, an infant Points to an object and the mother responds with a Point to indicate “This one?”.

Symbolic Play Act [SPA]. A Symbolic Play Acts is an appropriate action performed with a toy either independently or toward an agent (self, clinician, baby doll, Elmo). Any hand-over-hand maternal prompting of infants to perform symbolic play acts will be coded as an SPA for the mother. When two Symbolic Play Acts are performed, two separate Symbolic Play Acts will be coded. For example, scoop and feed is coded as two Symbolic Play Acts. Examples include:

• Pour, feed, eat, brush, drink with cup or bottle, stir, “cheers” (with cups or bottles), rock baby doll, or Elmo.

• Hug/kiss baby doll or Elmo; however hug/kiss mother or clinician will not be coded.

• Put lid on the frying pan will be coded; however, taking the lid off the frying pan will not be coded because this behaviour cannot be differentiated from simply picking up the lid.

• Bang an object for the purpose of animating the toy (e.g., making the frog jump).
**Gesture Strategy.** Gesture strategies describe how mothers use gestures to supplement their spoken language (Iverson, Longobardi, Spampinato, & Caselli 2006).

1. **Emphasize [E].** The gesture “reinforces” the verbal utterance by emphasizing or conveying the same meaning as their verbal utterance. Examples include:
   - All utterances paired with a *conventional* gesture and its verbal equivalent (e.g., All Gone + “all gone”, Nod + “yes”).
   - All utterances in which a referent is *labelled* anywhere in the language frame and indicated with a deictic gesture (e.g., Point to car + “car”). The referent can be labeled in a statement or question format.
   - All utterances with an *emphatic* gesture (e.g., Move Flat Hand Down + “That’s it!”).
   - All Representational gestures produced during the signing of the song will be coded as Emphasize since the words of the song emphasize the gestures produced in the song.
   - Gestures that “globally” reinforce the language (e.g., Arms Out + “There he is!”, Peek-a-Boo Hands + “Here I am”).

2. **Disambiguate [D].** The gesture disambiguates the message in the verbal utterance. The gesture identifies the precise referent of the verbal utterance but the referent is not labeled in the mother’s language. The mother’s language has a pronoun or locative but not a label. These are usually deictic gestures produced with:
   - Expressions used to direct the attention of the infant (e.g., Point + “Look!”, Show + “See?”).
   - Personal or object pronouns (“I,” “you,” “he,” “she,” “it,” “we,” “they”) and possessive pronouns (“mine,” “yours,” “his,” “hers,” “its,” “ours,” “theirs”).
   - Examples include: Show + “Mine,” Touch Point + “What is this?”
   - Demonstrative (“this,” “that”) and locative expressions (“here,” “there”).
   - Examples include: Point + “That one,” Show + “Here he is,” Show + “Who is it?”
3. **Add [ADD]**. The gesture adds information to the verbal utterance (i.e., the gesture and language contribute unique information). In this category the gesture contributes the referent information and the verbal utterance contains additional semantic information such as an attribute. If a deictic gesture is produced that identifies the referent and the language does not name the referent or refer to it with a preform these will be coded as Add. Examples include:

- Show+ “All done?”
- Show + “Want more?”
- Give + “You do it.”
- Give + “Brush baby’s hair.”

**Prompts.** Prompts describe the method used by mothers to encourage infant gestures.

1. **Model Prompt [M]:** the mother produces the gesture herself and:
   - Waits expectantly/pauses for one or more seconds following the use of the gesture.
   - Looks expectantly at infant.
   - Repeats the gesture.
   - Pairs gesture with a verbal prompt (described below).
2. **Verbal Prompt [V]:** the mother verbally directs the infant to produce the gesture (e.g. “Wave bye-bye,” or “You do it”).
3. **Physical Prompt [P]:** the mother physically manipulates the infant’s body to produce the gesture (e.g., takes the infant’s hand and makes it wave).
   - Physical prompts by the mother will not also be coded as maternal gesture (i.e., only the physical prompt is coded).